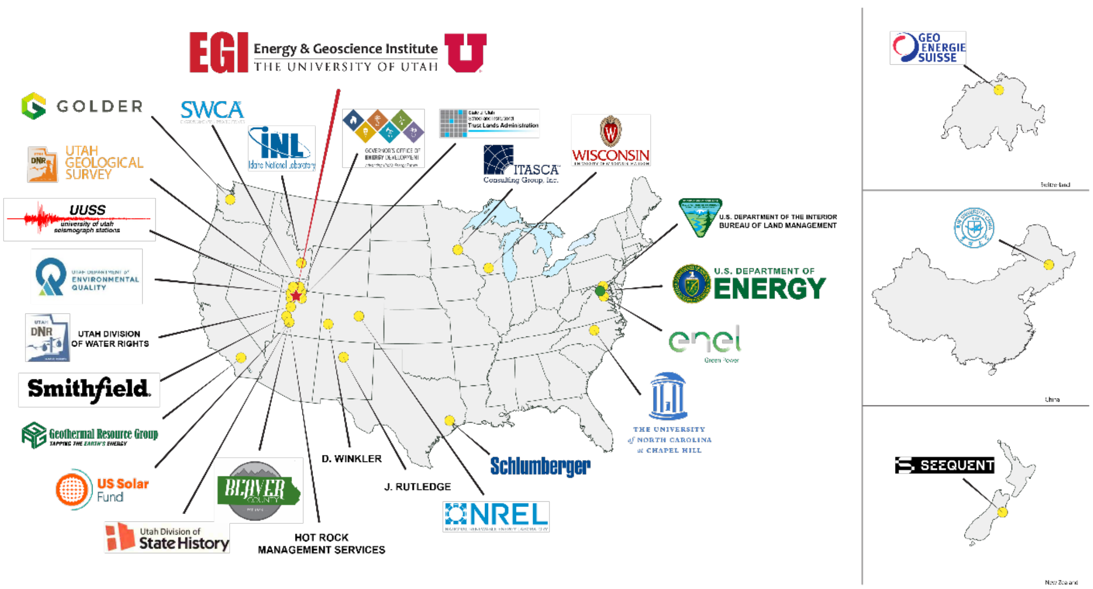
Geothermal Resource Group, Inc.
77530 Enfield Lane, Building E
Palm Desert, CA 92211
Phone: 760-341-0186

End of Well Report

Forge Seismic Monitoring Well 56-32

Milford, Utah



Prepared by:

Geothermal Resource Group, Inc.

for

University of Utah (UofU)

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Prepared by	Ernesto Rivas
	Sr. Drilling Engineer
	Sami Atalay
	Sr. Drilling Engineer
Reviewed by	Mary Mann
	Sr. Geoscientist
	W. M. Rickard
	President
Approved by	Joseph Moore
	Project Manager

Table of Contents

Figures

Tables

1. SUMMARY

Department of Energy FORGE initiative Phase 3B Well 56-32 was drilled to a depth of 9,145 ft. to be used as a closed monitoring well. Well 56-32 encountered the top of the granite at about 3,110 ft. The use of new PDC cutters and MSE allowed for an improvement in rate of penetration of more than 60% compared to well 16A-32 and 180% when compared to the first well drilled in the Utah FORGE project (58-32).

The well was cased with 5-1/2-inch casing to a depth of 9,105 ft. A suite of geophysical logs, pressure and temperature surveys, and image logs were run to obtain data. The drilling and testing of 56-32 well was completed deeper than planned, ahead of schedule and under budget.

2. ABBREVIATIONS AND ACRONYMS

The abbreviations and acronyms in Table 1 are used throughout the document, many of them are common acronyms and terms used in the drilling industry and may appear without explanation in the text. The reader is urged to refer to this table to become familiar with the terms as they are employed within the report. Table 2 contains the units of measure that were used during drilling and the abbreviations or symbols may occur through this report.

Important Note: All depths in this program are measured depths from the rotary Kelly bushing (RKB) level of 30.40 ft. above ground level, unless stated otherwise

Table 1 Abbreviations and Acronyms

Abbreviation or Acronyms	Description
ACP	annulus casing packer
AD	Alternative (special) drift
AFE	authorization for expenditure
API	American Petroleum Institute
ASL	above sea level
BGL	below ground level
BHA	bottom-hole assembly
BHST	bottom hole static temperature
BOP	blowout preventer
BOPE	blowout prevention equipment
BTC	buttress threaded and coupled
CO_2	carbon dioxide

Abbreviation or Acronyms	Description
DC	drill collar
DP	drill pipe
DSV	drilling supervisor
EOWR	end-of-well report
EMW	equivalent mud weight
FC	float collar
FG	fracture gradient
FIT	formation integrity test
FOSV	full opening safety valve
FS	float shoe
GL	ground level
GRG	Geothermal Resource Group, Inc.
H_2S	Hydrogen sulfide
HSE	health, safety, and environmental
HWDP	heavy weight drill pipe
IADC	International Association of Drilling Contractors
ID	inner diameter
JSA	job safety analysis
jt	Joint (casing, drill pipe)
Ksi	Kilopounds per Square Inch
KPI	key performance indicators
LCM	lost circulation material
LGS	low gravity solids
LOT	leak off test
LSR	Life-saving rules
LSND	low solids non-dispersed (drilling mud)
M/U	make up
MD	measured depth
MI/RU	move in and rig up
MSDS	material safety data sheet
MW	mud weight
N/U	nipple up

Abbreviation or Acronyms	Description
N/D	nipple down
NMDC	non-magnetic drill collar
NPT	national pipe thread
OD	outer diameter
P/U	pick up
PDC	polycrystalline diamond compact (bit)
PLC	partial loss of circulation
POH	pull out of hole
PoH	probability of hazard occurrence
PPB	pounds per barrel
PPF	pounds per foot
PPG	pounds per gallon
P/T or PT	pressure and temperature
PTS	pressure, temperature, and spinner logging / survey
PVT	pit volume totalizer
RD/MO	rig down and move off
ROP	Rate of Penetration
RMG	rig manager
sFIT	step-rate formation integrity test
TD	Total Depth or Termination Depth of hole or section
UofU	University of Utah
xLOT	extended leak off test

Table 2: Table of units and their symbols used during drilling of 56-32

Unit Category	Description	Symbol
Cost	Currency – daily cost and AFE amounts	$
Size/Diameter-1	Small diameter – bit nozzle diameter	1/32 in
Size/Diameter-2	Larger diameter – bit diameter, pipe OD	in or (”)
Dog Leg	Dog leg severity (DLS)	^{o}/100
Drilling Rate	Rate of penetration -- feet per hour	fph
FlowRate-1	Moderate flow rate – pump flow	gpm
FlowRate-2	Large flow rates – gas flow rate	scfm

Unit Category	Description	Symbol
FlowRate-3	Large flow rate - cement, mud/water loss	bpm
Fluid Density	Fluid density – mud weight/density	ppg
Gas	Gas concentrations – trip and connection gas	units
Length-1	Moderate length – depth	ft or (')
Length-2	Long lengths – visibility	mile
Pressure	Pressure – pump pressure	psi
Resistivity	Resistivity – geophysical survey	ohm.m
Temperature	Temperature – mud temperature	°F
Torque	Torque	ft-lb
Viscosity-1	Viscosity – funnel viscosity	sec /qt
Viscosity-2	Viscosity – plastic viscosity	cp
Volume-1	Small to moderate volume	gal
Volume-2	Large volume – mud/water/cement volume	bbl
Weight	Weight – WOB, hook load	lb
Weight per Length	Weight per unit of length - tubular	ppf
Yield Point	Yield point	lb /100 sqft

3. INTRODUCTION

Well 56-32, drilled vertically and completed to a depth of 9,105 ft. in a location that is advantageous for monitoring in relation to the final determined bottom hole location of the deep scientific well 16A-32, drilled in 2020. Well 56-32 is the 5th well drilled in the Milford area Utah Frontier Observatory for Research in Geothermal Energy (FORGE) Enhanced Geothermal System (EGS) site (Utah FORGE). The project is administered by the U.S. Department of Energy and managed by the University of Utah (U of U).

Specific objectives of 56-32 were to:

- Complete a closed monitoring well to 9,000 ft., with fiber optic seismic cable to 7,500 ft. cemented behind casing
- Evaluate mud hammer technologies in the bottom section of the hole (7,500 ft. to 9,000 ft.)
- Use of Mechanical Specific Energy (MSE) calculation to evaluate PDC bits performance in hard rock

The first two objectives were partially achieved:

- The fiber optic seismic cable was run to 7,500 ft, but the Silixa fiber optic cable failed in tension during the cementing of the 5-1/2 in. casing and does not function

- After drilling the 8-3/4 in. hole to 7,500ft. there were two attempts to use the mud hammer, but it failed to engage and drill the hole. Under these circumstances, the decision was made to complete the 8-3/4 in. hole with PDC bits

The third objective was successfully completed. By close monitoring MSE and adjusting drilling parameters as required, to keep the MSE value around 70Ksi, the well performance of the PDC bits was the best performance in any well drilled in this project.

The health and safety of all personal, and maintaining a clean, non-hazardous work environment (HSE), were the top priority during drilling and testing operations.

The safety and environmental standards of the U of U were implemented, achieving the following goals:

- No LTIs (lost time injuries or incidents)
- No environmental hazards and minimum environmental impact
- No major or catastrophic service quality incident

On location, the project HSE plan was implemented, including:

- The COVID-19 guidelines were implemented and followed. No cases were detected while drilling the well
- Daily safety meetings were held prior to each shift, addressing the importance of proper and safety conscious crew behavior
- Operation specific safety meetings with all personnel involved to identify safety risks and relevant precautions prior to specific tasks such as casing running, cementing, and logging
- Clear identification of muster areas at the location and clear lines communication for all personnel
- Safety drills were performed on a periodic basis

All detailed information including reports from service providers, daily drilling reports, BHAs, casing and cementing reports, mud log, geologic reports, drilling fluids reports, and other relevant documentation of operations are included as appendices to this report.

4. WELL INFORMATION

4.1. Well Location

The 58-32 well site is located within the 1.9 square-mile Utah FORGE deep drilling site, west of the Mineral Mountains, 217 miles south of Salt Lake City and 10 miles north-northeast of the town of Milford, Utah (Figure 1). The site is located in the Milford Energy Corridor in eastern Beaver County. The site is 10 miles north of Milford, the closest town, and 217 miles south of Salt Lake City. The project area is rural and covers approximately 15.5 miles^2. Figure 2 shows an aerial view of the surface locations for the Utah FORGE wells, drilled and planned. Table 3 contains the basic planned well information for well 56-32. All depth measurements in this report are referred to the rotary Kelly Bushing (RKB), unless otherwise noted.

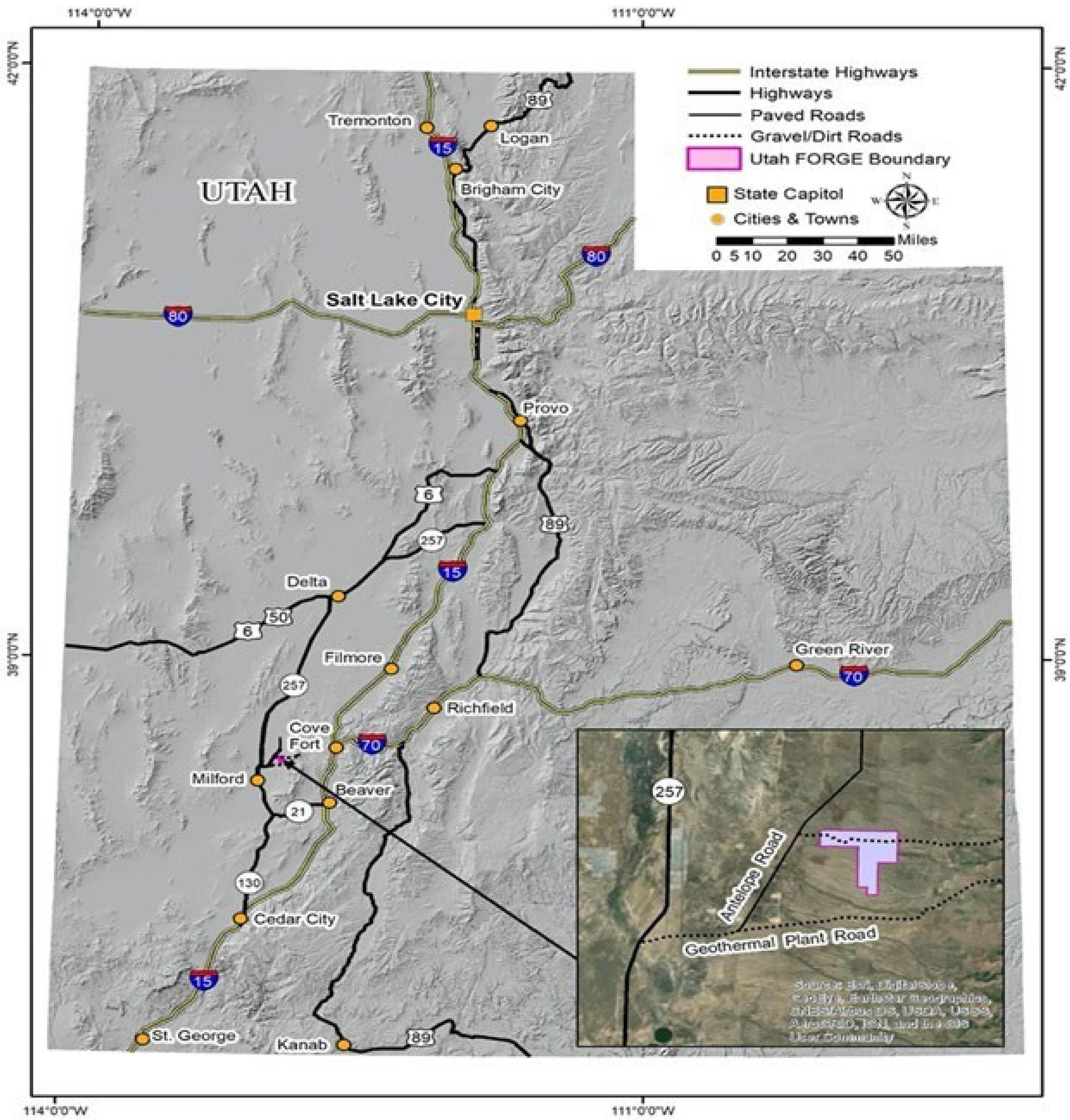


Figure 1: Utah FORGE project location.

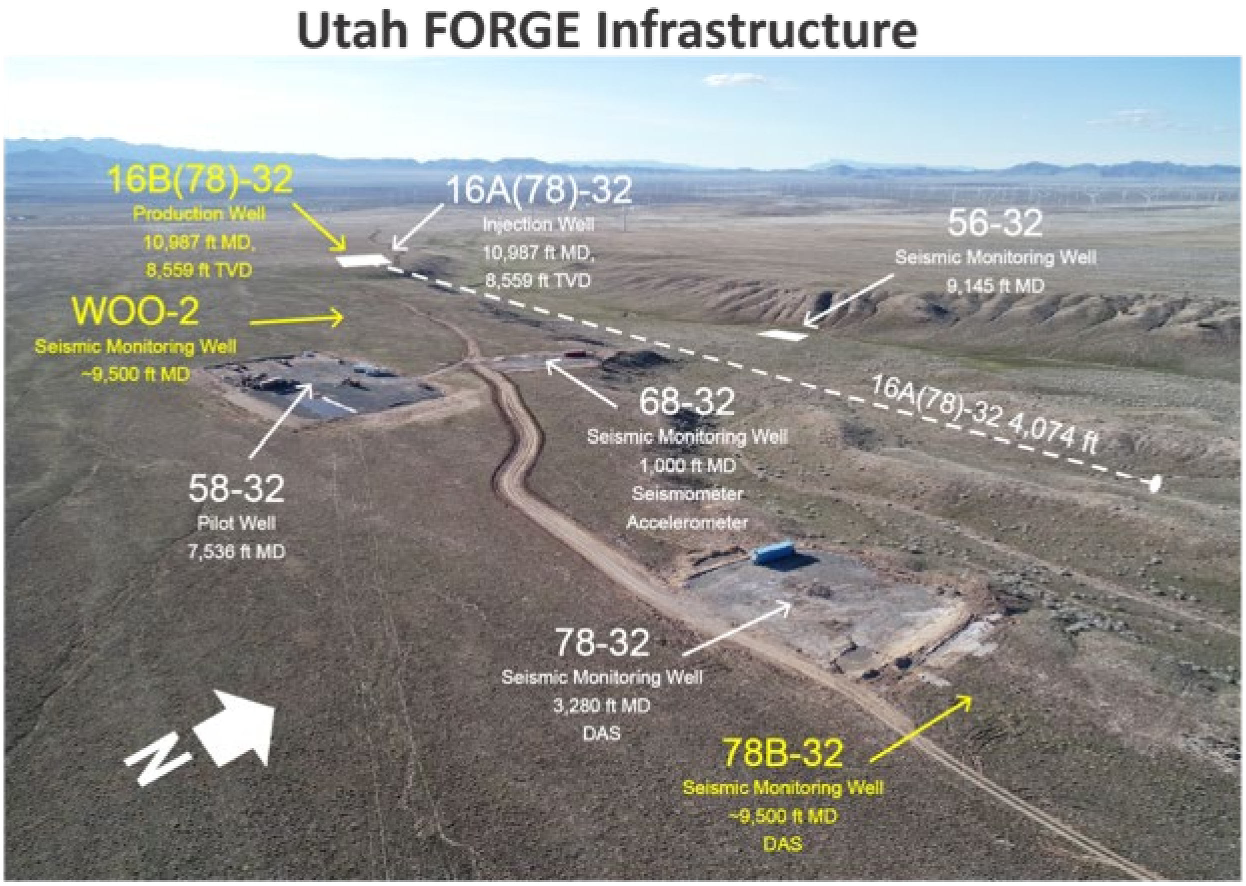


Figure 2: Aerial view of surface locations of Utah FORGE Wells. Drilled wells are shown in white, planned in yellow.

Table 3: 56-32 Well Information

Country/Area:	USA / Milford, UT
Field:	FORGE UTAH
Operator:	University of Utah (UofU)
Drilling Project Manager	Geothermal Resource Group (GRG)
Drilling Contractor (PM):	Frontier
Drilling Rig:	Rig-16
Well Name:	56-32
Well Type:	Mid-size, vertical, deep monitoring and testing well, well of opportunity

Well Location:	Utah FORGE, 56 Pad Northing: 335,511.095 Easting: 4,263,429.148
Coordinate Reference System:	NAD83, UTM Zone 12
Rotary Table Height:	30.40 ft. from ground level
Ground Level (GL):	5,451.71 ft. ASL
Rotary Table Elevation	5,482.11 ft. ASL
Planned Depth:	9,000 ft. (within 4° inclination from vertical at TD)
Actual Depth:	9,105 ft. (2.99° inclination at TD)

4.2. Planned Wellbore Construction and Well Plan

Well 56-32 was planned as a mid-size, vertical, EGS monitoring and testing well to a total depth of 9,000 ft. (Figure 3). A 20 in. conductor casing was to be set at 128 ft., a 17-1/2 in. surface hole with cemented 13-3/8 in. casing was planned to 350 ft., the intermediate 12-1/4 in. hole with cemented 9-5/8 in. casing was planned to 3,500 ft., below this an 8-3/4 in. hole to 9,000 ft. with cemented 5-1/2 in. casing to total depth.

Time to drill was estimated based on drilling performance of well 16A-32. The days versus depth plots were calculated prior to drilling and is shown in Figure 4. The estimated time was 38 days for drilling and testing. Actual drilling and testing were completed in 28 days from commencement of drilling and to a deeper TD of 9,105 ft.

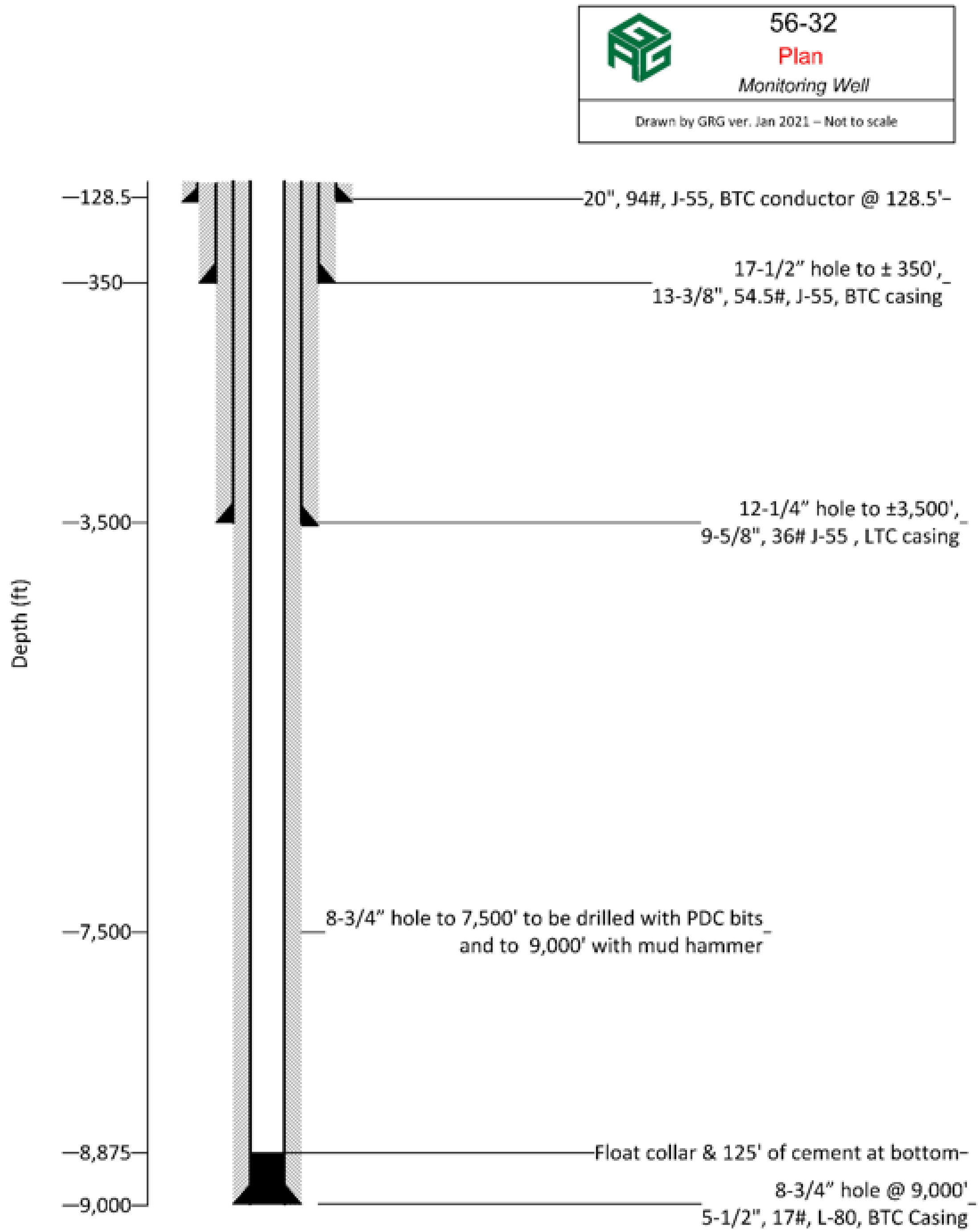


Figure 3: Planned well construction for 56-32

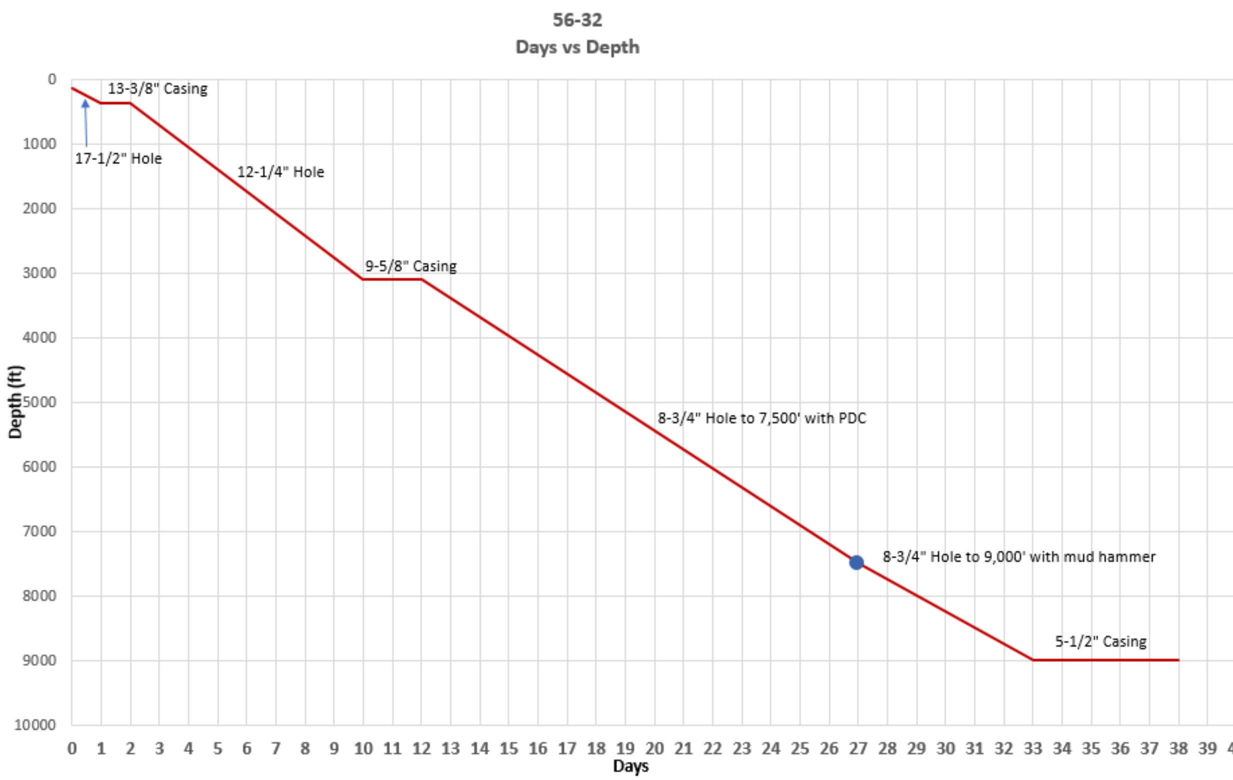


Figure 4: Planned days versus depth for well 56-32

4.3. Wellbore As Constructed

Table 4 Shows the casing specifications and depths for actual construction of the 56-32 wellbore.

Table 4: 56-32-hole sections, as constructed

Section	Hole Size (in.)	Casing Size (in.)	Specifications	Nominal ID/ Drift ID/ Coupling OD (in.)	Actual Depth (ft.)	Remarks
Conductor	n/a	20	94 ppf, J-55, Welded	19.124 18.936 n/a	120.5	Preset
Surface	17-1/2	13-3/8	54.5 ppf, J-55, BTC	12.615 12.459 14.375	381	Cemented well control string. Set in 100% alluvium

Section	Hole Size (in.)	Casing Size (in.)	Specifications	Nominal ID/ Drift ID/ Coupling OD (in.)	Actual Depth (ft.)	Remarks
Intermediate	12-1/4	9-5/8	36 ppf, J-55, LTC	8.835 8.765 10.625	3,494	Cemented intermediate string. Set in 100% granite
Production	8-3/4	5-1/2	17 ppf, L-80, BTC	4.892 4.767 6.3	9,135	Cemented. Set in 100% granite

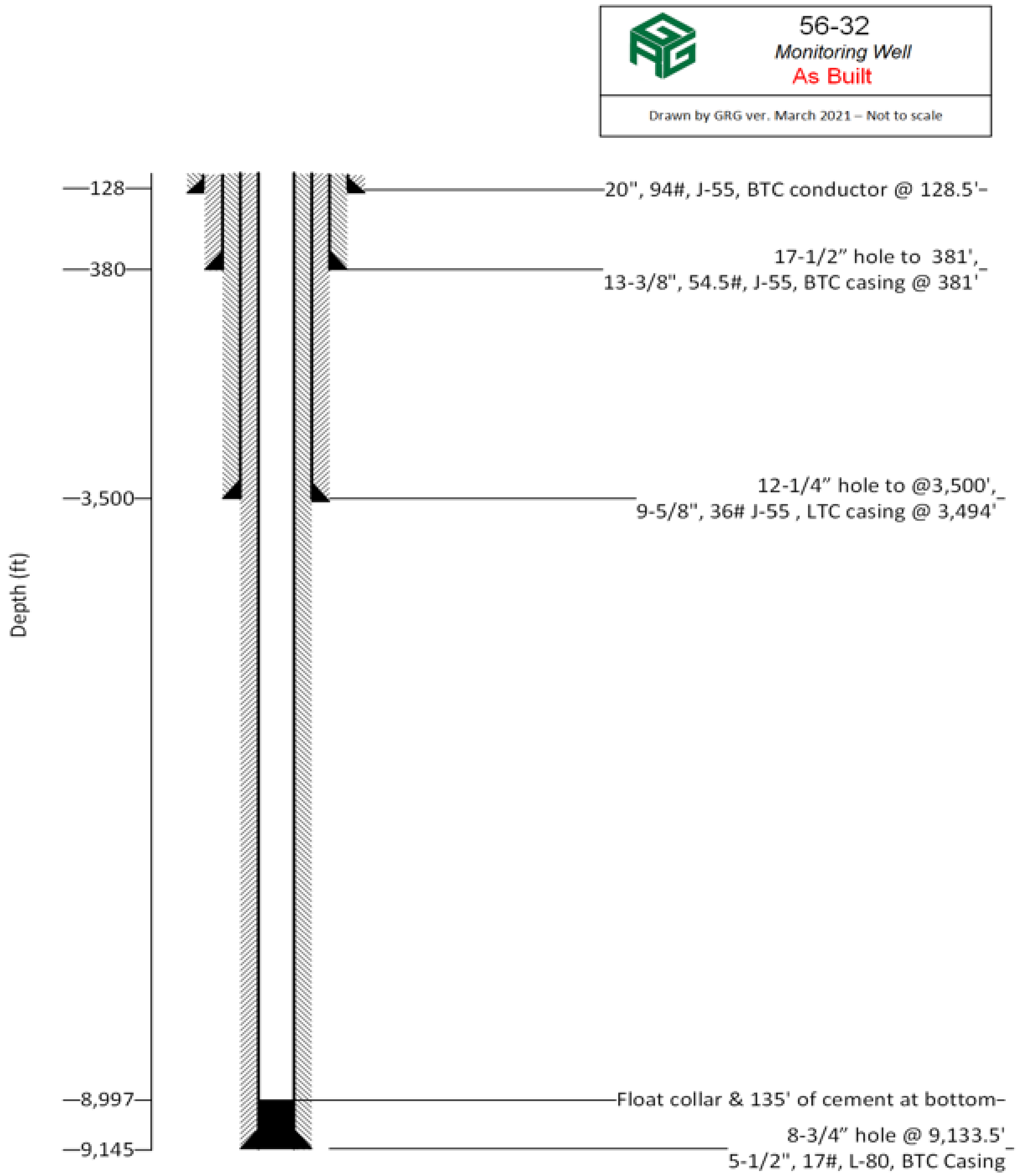


Figure 5: 56-32 well schematic, as built

4.4. Drilling Summary

Prior to rig mobilization, the well pad was constructed including setting of the cellar and drilling of mouse and rat holes. Additionally, the 20 in. conductor pipe was cemented with the casing shoe at 128.5 ft. on 13 January 2021. The Frontier Rig started mobilization from the 16A pad on 3 February 2021 and completed mobilization and rig up. Drilling commenced on 8 February 2021. The 17-1/2 in. hole was drilled to 381 ft. and 13 3/8 in. casing was cemented to 381 ft., on the same day. Drilling of the 12-1/4 in. hole commenced on 9 February and continued to 10 February, when the casing point of 3,500 ft. was reached. The 9-5/8 in. casing was set and cemented at 3,494 ft measured depth on the same day. The drilling of the 8 -3/4 in. hole commenced on 12 February, and total depth of 7,625 ft. was reached on 22 February.

The well was conditioned and the PDC pulled out of the hole. A mud hammer with 8-3/4 in. bit was run in the hole and reamed hole to 7,620 ft. Attempted to mud hammer drill rotating and drilling 8-3/4 in. hole from 7,620 ft. to 7,627 ft. but mud hammer did not fire. It was suspected that the wellbore needed to be reamed with 2x8-3/4 in. roller reamer to allow the mud hammer to engage. This reaming was performed on 22 to 23 February. The second mud hammer was run and attempted to drilled 8-3/4 in. from 7,627 to 7,662 ft., but hammer failed to engage again. It was decided then to continue drilling the 8-3/4 in. hole with PDC bits while taking apart the mud hammers and attempt to trouble shoot them. By taking apart the mud hammers, it was noticed they were not fit to be used with current drilling mud.

Drilling continued with 8-3/4 in. PDC to 9,145 ft. and a Triple Combo and Gyro was run at total depth. A lateral core was attempted but failed to be cut, because the core bits were not able to cut into the formation that is hard granite.

The hole was conditioned and the 5-1/2 in. casing with Silixa optic cable was run from 9,145 ft. back to surface. Cementing of the 5-1/2 in. casing started on 2 March 2021 without cement returns back to surface. During the cement job it was suspected that there was a bridge in the hole-by-casing annulus and the 5-1/2 in. casing string was reciprocated with hopes of regaining circulation, which it was not. It was later discovered that this action caused the Silixa to part in tension. The annulus-by-annulus casing was flushed with water to perform a top squeeze and top fill. The cement inside the 5-1/2 in. couldn't be displaced and it set, requiring it to be drilled after completing the cementing of the outside of the casing. This early setting of the cement has been investigated and determined that the mistake was not in the cement blend (though silica additive may have been a factor), but the actual mixing of the blend, a mis-counting of actual sacks of product going into the hopper at the cement shop was the root cause. It is recommended that a physical count be documented by cement service company on future jobs. Cement was cleaned out in one run with 4-3/4 in. PDC bit to 9,032 ft. depth (7,325 ft.) in 35.5 hours with an instantaneous ROP of just over 300 fph.

The rig was released on 9 March 2021.

4.5. Days vs Depth

Well 56-32 was drilled to a total depth of 9,145 ft., 145 ft. deeper than the planned depth of 9,000 ft. and in less time than anticipated (Figure 6). The expected rate of penetration (ROP) was based on the PDC performance of well 16A-32. Improvements in the use of MSE allowed for 56-32 to be drilled 60% faster than anticipated. Several types of PDC bits were tested within the granitic section, which led to improved performance. Removing the shock sub from the BHA allowed improved the life of the mud motors, allowing them to stay in the hole over 20 hours and in turn meant that each bit was able to drill more footage. Two of the last used 8-3/4 in. PDC bits drilled more than 1,000 ft. each (1,089 and 1,234 ft., respectively), which has never been achieved in this hard formation in any other drilling operation that we have heard of. The well reached TD 13 days ahead of plan. The failure while cementing the 5-1/2 in. casing added about 6 days to the completion activities for the well, and the well was completed in a total of 28 days compared to the planned 38 days.

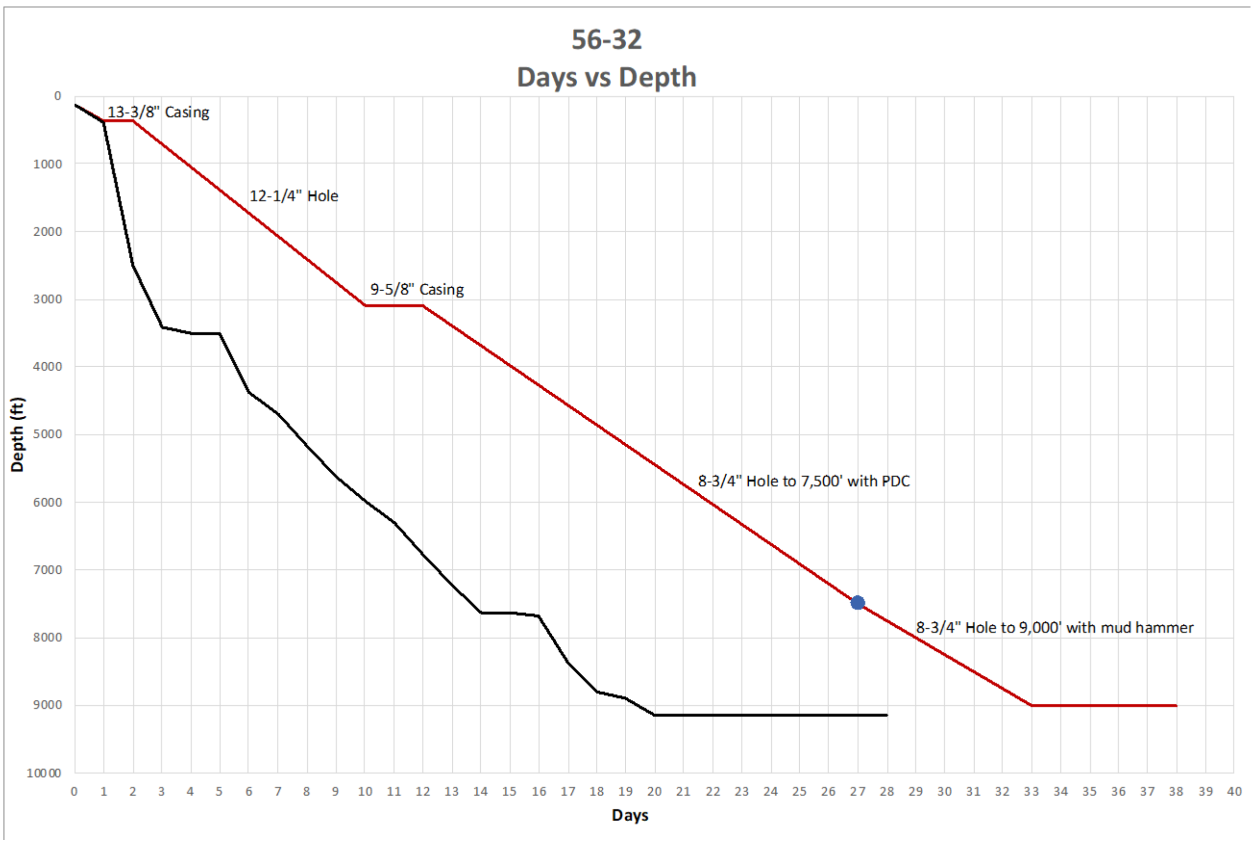


Figure 6: Planned (red) versus actual (black) drilling days plot for 56-32.

5. DIRECTIONAL PROGRAM

Well 56-32 was designed as a vertical well. Directional MWD surveys were taken frequently along the wellbore with correctional sliding drilling performed as needed to maintain verticality. Close monitoring was possible, as the well was completely drilled with mud motor and MWD. The survey results from surface to TD are shown in Table 5 the final Total Measured Depth 9,145 ft. and True Vertical Depth is 9,138.3 ft., as calculated by the directional drilling services provider. The final plot is shown in Figure 7.

Table 5: Survey data for 56-32

Survey Type	Measured Depth	Inc (deg)	Azimuth (deg)	TVD (ft)	Coordinates N-S (ft)	Coordinates E-W (ft)	Closure (ft)	Vertical Section (ft)	Dogleg Severity
**TieIn	0.0	0.00	0	0.0	0.0	0.0		0.0	
MWD	201.0	0.22	63.64	201.0	0.2	0.3	0.4	0.2	0.109
MWD	292.0	0.43	44.92	292.0	0.5	0.7	0.9	0.5	0.256
MWD	401.0	0.70	31.38	401.0	1.3	1.4	1.9	1.3	0.275
MWD	493.0	0.70	352.1	493.0	2.4	1.6	2.9	2.4	0.511
MWD	585.0	1.14	358.25	585.0	3.9	1.5	4.1	3.9	0.489
MWD	676.0	1.05	258.25	676.0	4.6	0.6	4.6	4.6	1.845
MWD	767.0	1.36	355	767.0	5.5	-0.3	5.5	5.5	1.992
MWD	858.0	1.54	7.21	857.9	7.8	-0.2	7.8	7.8	0.392
MWD	949.0	1.41	6.33	948.9	10.1	0.1	10.1	10.1	0.145
MWD	1,040.0	1.54	10.46	1,039.9	12.4	0.4	12.4	12.4	0.184
MWD	1,135.0	1.71	5.63	1,134.8	15.1	0.8	15.1	15.1	0.230
MWD	1,230.0	1.85	13.45	1,229.8	18.0	1.3	18.0	18.0	0.295
MWD	1,325.0	1.85	16.88	1,324.7	21.0	2.1	21.1	21.0	0.117
MWD	1,419.0	2.02	16.7	1,418.7	24.0	3.0	24.2	24.0	0.181
MWD	1,514.0	1.36	30.5	1,513.6	26.6	4.1	26.9	26.6	0.811
MWD	1,608.0	1.54	37.53	1,607.6	28.5	5.4	29.0	28.5	0.269
MWD	1,703.0	1.71	43.6	1,702.6	30.6	7.1	31.4	30.6	0.254
MWD	1,798.0	1.98	49.14	1,797.5	32.7	9.4	34.0	32.7	0.340

Survey Type	Measured Depth	Inc (deg)	Azimuth (deg)	TVD (ft)	Coordinates		Closure (ft)	Vertical Section (ft)	Dogleg Severity
					N-S (ft)	E-W (ft)			
MWD	1,892.0	1.36	55.82	1,891.5	34.4	11.5	36.2	34.4	0.690
MWD	1,986.0	1.27	71.72	1,985.5	35.3	13.4	37.8	35.3	0.398
MWD	2,081.0	1.45	63.02	2,080.4	36.2	15.5	39.4	36.2	0.288
MWD	2,175.0	1.23	72.43	2,174.4	37.0	17.5	41.0	37.0	0.330
MWD	2,270.0	1.49	60.74	2,269.4	37.9	19.6	42.7	37.9	0.399
MWD	2,365.0	1.36	74.27	2,364.3	38.9	21.7	44.5	38.9	0.379
MWD	2,458.0	1.32	71.2	2,457.3	39.5	23.8	46.1	39.5	0.088
MWD	2,551.0	1.67	73.66	2,550.3	40.2	26.1	48.0	40.2	0.383
MWD	2,648.0	2.02	78.93	2,647.2	40.9	29.2	50.3	40.9	0.401
MWD	2,743.0	2.02	85.26	2,742.2	41.4	32.5	52.6	41.4	0.235
MWD	2,839.0	1.54	70.32	2,838.1	42.0	35.4	54.9	42.0	0.691
MWD	2,934.0	1.27	61.7	2,933.1	42.9	37.5	57.0	42.9	0.360
MWD	3,029.0	1.80	66.01	3,028.1	44.0	39.8	59.3	44.0	0.571
MWD	3,124.0	0.97	100.38	3,123.0	44.5	41.9	61.1	44.5	1.199
MWD	3,219.0	0.70	92.55	3,218.0	44.3	43.3	62.0	44.3	0.308
MWD	3,314.0	1.41	113.56	3,313.0	43.8	45.0	62.8	43.8	0.839
MWD	3,410.0	1.49	110.57	3,409.0	42.9	47.2	63.8	42.9	0.115
MWD	3,447.0	1.45	119.54	3,446.0	42.5	48.1	64.2	42.5	0.631
MWD	3,497.0	1.45	119.71	3,496.0	41.9	49.2	64.6	41.9	0.009
MWD	3,592.0	0.09	235.73	3,590.9	41.2	50.2	64.9	41.2	1.570
MWD	3,687.0	1.19	275.81	3,685.9	41.3	49.1	64.2	41.3	1.182
MWD	3,792.0	1.14	257.35	3,790.9	41.2	47.0	62.5	41.2	0.359

Survey Type	Measured Depth	Inc (deg)	Azimuth (deg)	TVD (ft)	Coordinates		Closure (ft)	Vertical Section (ft)	Dogleg Severity
					N-S (ft)	E-W (ft)			
MWD	3,877.0	1.71	259.02	3,875.9	40.8	44.9	60.7	40.8	0.672
MWD	3,972.0	2.37	239.68	3,970.8	39.5	41.9	57.5	39.5	0.995
MWD	4,067.0	0.88	14.51	4,065.8	39.2	40.3	56.3	39.2	3.216
MWD	4,163.0	0.70	68.65	4,161.8	40.1	41.1	57.4	40.1	0.767
MWD	4,258.0	1.14	248.47	4,256.8	40.0	40.7	57.1	40.0	1.937
MWD	4,353.0	1.89	253.31	4,351.8	39.2	38.4	54.8	39.2	0.800
MWD	4,448.0	1.19	338.56	4,446.7	39.7	36.5	53.9	39.7	2.261
MWD	4,544.0	3.34	310.96	4,542.7	42.4	34.0	54.4	42.4	2.449
MWD	4,640.0	2.02	246.1	4,638.6	43.6	30.4	53.1	43.6	3.211
MWD	4,734.0	1.27	30.85	4,732.6	43.8	29.4	52.7	43.8	3.344
MWD	4,829.0	0.70	7.29	4,827.5	45.3	30.0	54.3	45.3	0.724
MWD	4,924.0	0.84	3.61	4,922.5	46.6	30.1	55.4	46.6	0.156
MWD	5,018.0	0.75	295.93	5,016.5	47.5	29.6	56.0	47.5	0.945
MWD	5,113.0	1.85	211.03	5,111.5	46.5	28.2	54.4	46.5	2.035
MWD	5,208.0	2.42	23.91	5,206.5	47.0	28.3	54.8	47.0	4.486
MWD	5,302.0	2.68	273.61	5,300.4	48.9	26.9	55.8	48.9	4.455
MWD	5,397.0	1.96	289.22	5,395.3	49.6	23.1	54.7	49.6	1.002
MWD	5,492.0	3.92	267.35	5,490.2	50.0	18.3	53.3	50.0	2.341
MWD	5,587.0	6.34	263.45	5,584.8	49.3	9.9	50.2	49.3	2.572
MWD	5,681.0	5.97	255.77	5,678.3	47.5	-0.0	47.5	47.5	0.959
MWD	5,776.0	4.04	248.12	5,772.9	45.0	-7.9	45.7	45.0	2.145
MWD	5,871.0	4.02	254.32	5,867.7	42.9	-14.2	45.1	42.9	0.459

Survey Type	Measured Depth	Inc (deg)	Azimuth (deg)	TVD (ft)	Coordinates		Closure (ft)	Vertical Section (ft)	Dogleg Severity
					N-S (ft)	E-W (ft)			
MWD	5,954.0	4.02	231.45	5,950.5	40.3	-19.3	44.6	40.3	1.919
MWD	6,049.0	3.45	191.93	6,045.3	35.4	-22.5	41.9	35.4	2.716
MWD	6,144.0	2.73	190.1	6,140.2	30.4	-23.5	38.4	30.4	0.765
MWD	6,238.0	0.77	198.5	6,234.1	27.6	-24.1	36.6	27.6	2.097
MWD	6,333.0	1.45	232.32	6,329.1	26.2	-25.2	36.4	26.2	0.965
MWD	6,428.0	2.80	243.67	6,424.0	24.4	-28.2	37.4	24.4	1.482
MWD	6,523.0	2.49	239.04	6,518.9	22.4	-32.1	39.1	22.4	0.396
MWD	6,619.0	2.03	255.21	6,614.9	20.8	-35.5	41.2	20.8	0.814
MWD	6,713.0	0.71	244.52	6,708.8	20.2	-37.7	42.7	20.2	1.424
MWD	6,808.0	1.51	223.95	6,803.8	19.0	-39.1	43.4	19.0	0.928
MWD	6,902.0	2.28	225.96	6,897.8	16.8	-41.3	44.6	16.8	0.822
MWD	6,998.0	2.12	223.09	6,993.7	14.2	-43.9	46.1	14.2	0.202
MWD	7,093.0	1.58	233.46	7,088.6	12.1	-46.1	47.7	12.1	0.667
MWD	7,187.0	1.11	207.96	7,182.6	10.6	-47.6	48.7	10.6	0.798
MWD	7,281.0	1.49	226.8	7,276.6	8.9	-48.9	49.7	8.9	0.603
MWD	7,471.0	1.80	195.54	7,466.5	4.4	-51.5	51.7	4.4	0.492
MWD	7,566.0	2.35	198.56	7,561.5	1.1	-52.5	52.5	1.1	0.590
MWD	7,693.0	3.78	209.82	7,688.3	-5.0	-55.4	55.7	-5.0	1.216
MWD	7,788.0	2.83	205.09	7,783.1	-9.9	-58.0	58.8	-9.9	1.040
MWD	7,883.0	2.40	187.52	7,878.0	-14.0	-59.2	60.9	-14.0	0.952
MWD	7,977.0	3.49	215.53	7,971.9	-18.2	-61.2	63.8	-18.2	1.888
MWD	8,071.0	1.86	235.78	8,065.8	-21.4	-64.1	67.6	-21.4	1.979

Survey Type	Measured Depth	Inc (deg)	Azimuth (deg)	TVD (ft)	Coordinates		Closure (ft)	Vertical Section (ft)	Dogleg Severity
					N-S (ft)	E-W (ft)			
MWD	8,166.0	0.75	258.68	8,160.8	-22.4	-66.0	69.7	-22.4	1.268
MWD	8,260.0	1.39	294.03	8,254.7	-22.1	-67.6	71.1	-22.1	0.948
MWD	8,355.0	2.45	290.59	8,349.7	-20.9	-70.6	73.6	-20.9	1.122
MWD	8,450.0	1.75	310.26	8,444.6	-19.2	-73.6	76.0	-19.2	1.047
MWD	8,545.0	5.06	292.8	8,539.5	-16.7	-78.5	80.3	-16.7	3.612
MWD	8,640.0	5.84	284.86	8,634.0	-13.8	-87.1	88.2	-13.8	1.140
MWD	8,735.0	4.18	281.32	8,728.7	-11.9	-95.1	95.9	-11.9	1.777
MWD	8,831.0	2.49	148.99	8,824.6	-13.0	-97.5	98.4	-13.0	6.395
MWD	8,927.0	2.44	260.67	8,920.5	-15.1	-98.4	99.6	-15.1	4.249
MWD	9,021.0	1.84	230.13	9,014.5	-16.4	-101.6	102.9	-16.4	1.348
MWD	9,093.0	2.99	239.87	9,086.4	-18.1	-104.1	105.6	-18.1	1.690
MWD	9,145.0	2.99	239.87	9,138.3	-19.5	-106.4	108.2	-19.5	0.000

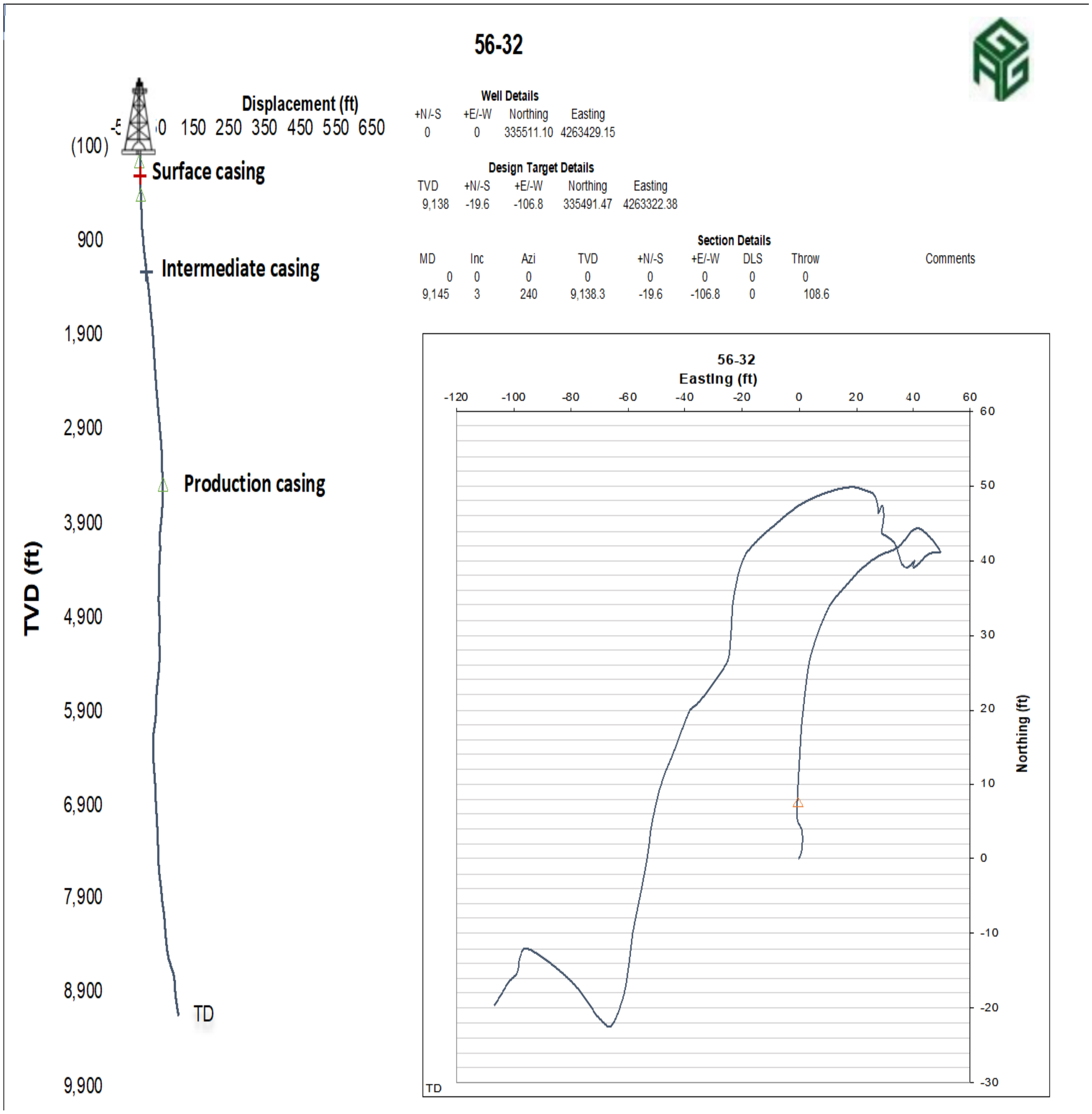


Figure 7: Final directional survey plot

6. DRILLING ACTIVITY BY WELL SECTION

6.1. Mob, Site Prep, Conductor

Cellar was constructed on January 12 by Peter Martin drilling company by installing a 10 ft. diameter cellar and by setting and cementing a 20 in. conductor pipe to 101 ft. below ground level on the next day (Figure 8 to Figure 11)

Figure 8: 56-32 cellar construction

Figure 9: 20 in. conductor pipe

Mouse hole was drilled to 75 ft. below ground level and a 14 in. pipe was installed and cemented to surface and a 1 ft. cement bottom was poured (Figure 10 and Figure 11)

Figure 10: Conductor and mouse hole

Figure 11: Cellar with conductor and mouse hole in cemented cellar

6.2. 17-1/2 in. Hole to 350 ft., 13-3/8 in. Casing

6.2.1. Drilling Objectives

Drilling objectives for the 17-1/2 in. hole section of the well were:

- Drill 17-1/2 in. section from 20 in. conductor shoe at 128.5 to the 13-3/8 in. casing shoe depth at 350ft. in a single bit run
- Case-off shallow unconsolidated formations, gas zones, and loss zones, if encountered
- Drill to sufficient casing depth to install the BOPE
- Maintain vertical well bore within 1.2° and stabilize wellbore hazards

6.2.2. Summary

Drilling of the 17-1/2 in. hole began on 8 February from the bottom of the 20 in. conductor casing at 128.5 ft. Drilling to the casing point at 380.5 ft. was accomplished the same day without incident. The 13-3/8 in. 54.5#, J-55, BTC casing was run to 380.5 ft. No circulation losses were found in this section and the wellbore inclination was within 0.5° at TD of section.

6.2.3. 17-1/2 in. Surface Equipment

The 17-1/2 in. section was drilled using a flowline directly from a 20 in. riser welded to the conductor. No additional blow out prevention equipment (BOPE) was required for this section of the well.

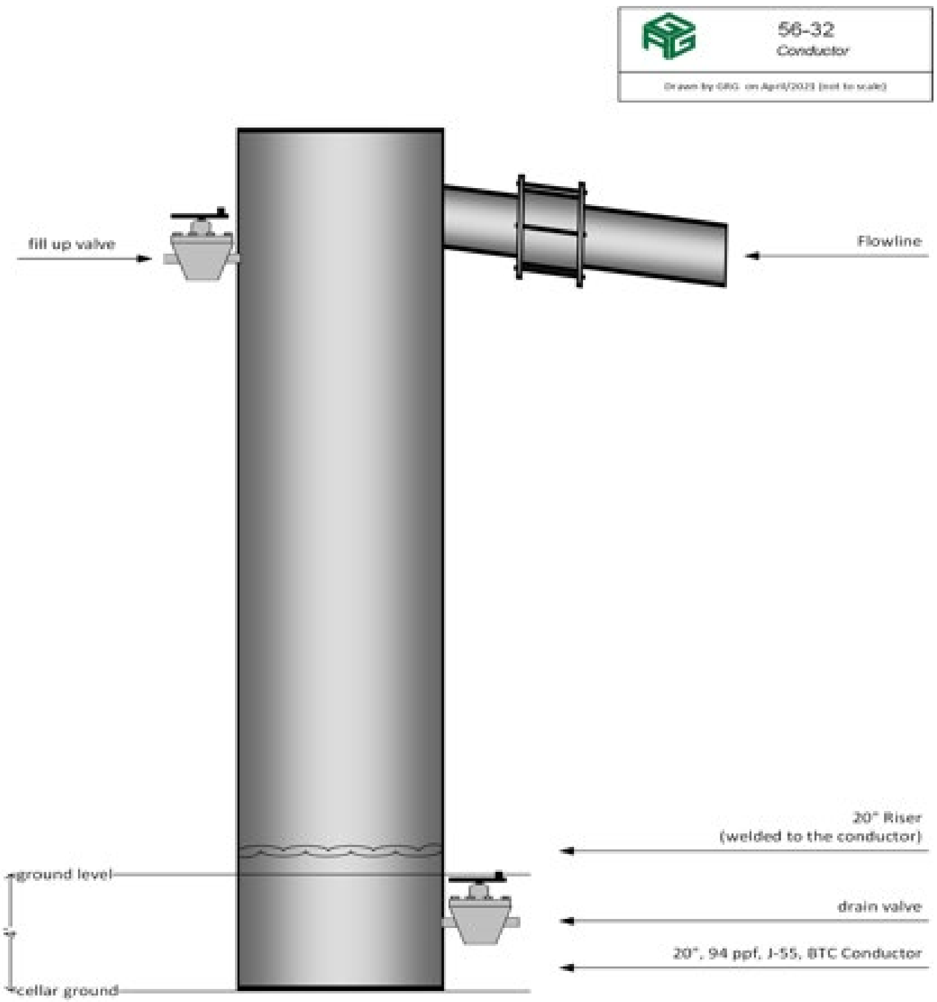


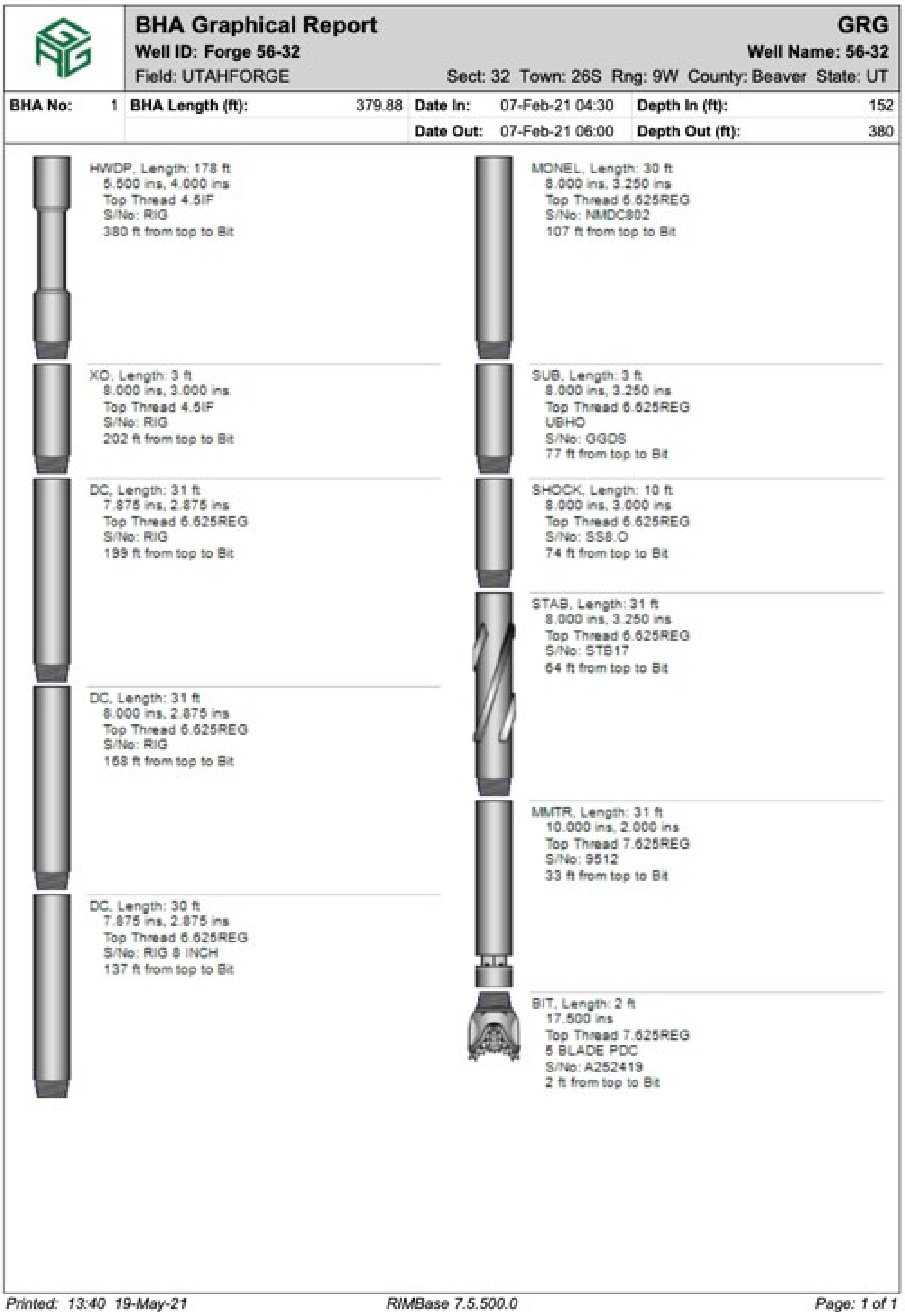
Figure 12: 20 in. Conductor stack, used for drilling 17-1/2 in. hole.

6.2.4. 17-1/2 in. Bit, Hydraulics Program and BHA

A new 17-1/2 in. 5-blade PDC bit was used to drill the 17-1/2 in. section from 128.5 ft. to 380.5 ft. The bit parameters and basic drilling parameters shown in Table 6 were used. Bit selection was based on drilling performance of the previous wells (58-32 and 16A-32). The bottom hole assembly consisted of the bit, positive displacement mud motor, a near bit stabilizer, a shock sub, an UBHO sub, a non-magnetic drill collar, three drill collars, a cross-over sub and a heavy weight drill pipe for a total length of 380 ft. (Figure 13).

Table 6: Basic drilling parameters for 17-1/2 in. section

Bit #/Run	Hole made (ft)	Bit Size (in.)	IADC Code	Ave. WOB (klbs)	Ave. RPM	Jet Size (32nd)	Ave. flow rate (gpm)	Ave. ROP (fph)
1/1	252	17.5	S422	12	50	20-20-20-20-20	800	206



BHA Graphical Report GRG

Well ID: Forge 56-32 — Well Name: 56-32

Field: UTAHFORGE — Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	1	BHA Length (ft):	379.88	Date In:	07-Feb-21 04:30	Depth In (ft):	152
				Date Out:	07-Feb-21 06:00	Depth Out (ft):	380

HWDP, Length: 178 ft
5.500 ins, 4.000 ins
Top Thread 4.5IF
S/No: RIG
380 ft from top to Bit

XO, Length: 3 ft
8.000 ins, 3.000 ins
Top Thread 4.5IF
S/No: RIG
202 ft from top to Bit

DC, Length: 31 ft
7.875 ins, 2.875 ins
Top Thread 6.625REG
S/No: RIG
199 ft from top to Bit

DC, Length: 31 ft
8.000 ins, 2.875 ins
Top Thread 6.625REG
S/No: RIG
168 ft from top to Bit

DC, Length: 30 ft
7.875 ins, 2.875 ins
Top Thread 6.625REG
S/No: RIG 8 INCH
137 ft from top to Bit

MONEL, Length: 30 ft
8.000 ins, 3.250 ins
Top Thread 6.625REG
S/No: NMDC802
107 ft from top to Bit

SUB, Length: 3 ft
8.000 ins, 3.250 ins
Top Thread 6.625REG
UBHO
S/No: GGDS
77 ft from top to Bit

SHOCK, Length: 10 ft
8.000 ins, 3.000 ins
Top Thread 6.625REG
S/No: SS8.O
74 ft from top to Bit

STAB, Length: 31 ft
8.000 ins, 3.250 ins
Top Thread 6.625REG
S/No: STB17
64 ft from top to Bit

MMTR, Length: 31 ft
10.000 ins, 2.000 ins
Top Thread 7.625REG
S/No: 9512
33 ft from top to Bit

BIT, Length: 2 ft
17.500 ins
Top Thread 7.625REG
5 BLADE PDC
S/No: A252419
2 ft from top to Bit

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Figure 13: BHA # 1, used bit # 1

6.2.5. 17-1/2 in. Drilling Fluids

Planned basic drilling parameters and the design of the mud system for the 17-1/2 in. drilling sections are shown in Table 7 and the average parameters used are shown in Table 8. The spud mud was designed as a pre-hydrated gel mud blended with 3% (4 ppb) fine micronized cellulose. The accepted mud program included the maintenance of 3% micronized cellulose.

Table 7: Fluid parameters planned for 17-1/2 in. section

Hole Size	17-1/2 in.
Casing Size	13-3/8 in.
Mud Type	Lime/Gel/Water System
Mud Weight (ppg)	8.6 – 9.2
Viscosity (sec)	50-60+
Filtrate (ML)	< 20
Total Mud Volume	400 bbls (300 bbls surface volume)
Directional Program	NA – Vertical Hole
Formations	Surface Alluvium
Interval BHT	< 100ºF
Drill 17-1/2 in. with flocculated Clay-based mud system; add Gel and Soda Ash/Caustic Soda as needed to maintain adequate viscosity for good hole cleaning (PV alap, YP 25+). Use Bentonite/Sawdust/Polyvis (PHPA) to sweep and stabilize hole as needed; thin mud with Desco CF/water. If encountered, control lost circulation with conventional LCM pills. Run and cement 13-3/8 in. casing	

Table 8: Average fluid properties for 17-1/2 in. section.

Fluid Parameters (spud)	Unit	Min	Max	Ave
Mud Weight	ppg	8.7	8.7	8.7
pH		8	10	8.75
API Fluid Loss (Filtrate)	cc/30 sec.	13.3	18.2	15.75
Plastic Viscosity	cP	12	22	17
Yield Point	$lb/100ft^2$	10	21	15.5

6.2.6. 13-3/8 in. Casing and Cementing

The 13-3/8 in., 54.5 ppf, J-55 casing was set at 380.5 ft., and cemented with centralizers at 370 ft., 225ft., 110 ft., and 60 ft. The cement report is shown in (Table 9). Good cement returns held at surface and after 5.5 hours waiting on cement (WOC), the 13-5/8 in. 3M x 5M Sliplok wellhead (w/ 2 ea. 2-1/16 in. x 5M side outlets) was installed and tested.

Table 9: Cement report for 13-3/8 in. casing

Cement Job Information			
Start Date/Time:	08-Feb-21 13:30	Wellbore:	Original Wellbore
Job Type:	PRIMARY	String OD (ins):	13.375
Well Section:	SURF	String Type:	FULL
Cementing Co:	Resource	Cementing Engineer:	Alex

Primary Job Detail				
	Volume (bbls)	Pump Time	Rate (bbls/min)	Pressure (psi)
Conditioning Data:		60	5.0	1,000
Cement Data:	97.0	20	5.0	1,100
Displacement Data:	52.0	10	5.0	1,000
Calc. Displacement Vol:				
☐ Reciprocate Pipe?	☑ Batch Mix?	☑ Bump Plug?	Bump Pressure:	1,600
Returns to Surface:	FULL	☑ Cement at Surface?	Volume (bbls):	200.0
Calc Top of Cement (ft):	0	Excess (%):	Avg. Hole Size (ins):	17.500

Slurry Information						
Type	Density	Yield	Sacks	Volume	Rate	Additives
OTHER	14.00	2.02	270	97.0	5.0	Thermalite mix

Post Job Information			
Liner Top Test (lbs/gal):		Job Success?	No
Actual Top of Cmt (ft):		CBL Bond Quality:	
Misc. Comments:	Good cement to surface. Pumped 10 bbls of fresh water, 30 bbls of 10.5 ppg Speiolite Spacer, 13 bbls of Sodium Silicate, 5 bbls of Fresh Water and 97 bbls of 14 ppg RC ThermaLite-A Cement. Drop top plug and displaced with 52.25 bbls of fresh water. Bump pluge with 1,600 psi		

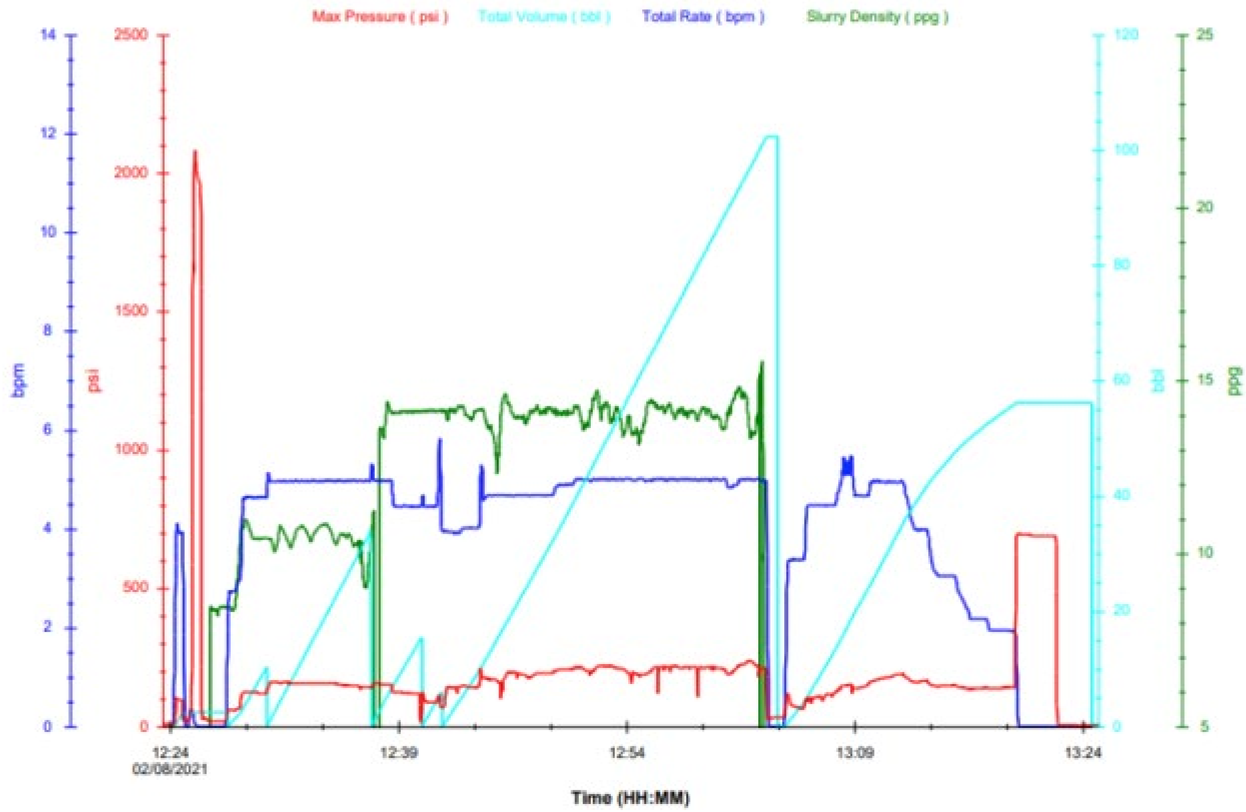


Figure 14: 13-3/8 in. surface casing cement pressure chart

6.3. 12-1/4 in. Hole to 3,500 ft., 9-5/8 in. Casing

6.3.1. 12-1/4 in. Hole Objectives

The drilling objectives for the 12-1/4 in. section were:

- Drill the cement inside the 13-3/8 in. shoe track (±40 ft) and ~2,750 ft. of new hole from the 13-3/8 in. casing shoe depth of 3,500 ft. (13-3/8 in. casing shoe depth) in a single bit run
- Maintain verticality within 4° and stabilize wellbore hazards
- Drill fast to reduce the wellbore exposure to the drilling fluid

All these objectives were achieved.

6.3.2. 12-1/4 in. Summary

After 6.5 hours waiting on cement, the 13-5/8 in. clamp-on well head was installed and tested. After the BOPE was installed and tested, cement and float shoe were drilled to 380 ft. and new hole was drilled to 390 ft. A Formation Integrity Test (FIT) gave a maximum allowable mud weight of 16 ppg for the next drilling section. The 12-1/4 in. vertical hole was drilled to 3,500 ft. between 9 and 11 February. The 9-5/8 in. casing was set at 3,494 ft. and cemented. No circulation losses, reactive clays or kicks were found in this section. The wellbore deviation was 1.45° at section TD.

6.3.3. 12-1/4 in. Surface Equipment

The BOPE used for the 12-3/4 in. drilling section is shown in (Figure 15), consisting of a 13-5/8 in. 5M double gate preventer and a 13-5/8 in. 5M annular preventer as the main elements. The equipment was function tested and pressure charts were sent to a Utah Department of Natural Resources representative on 12 February.

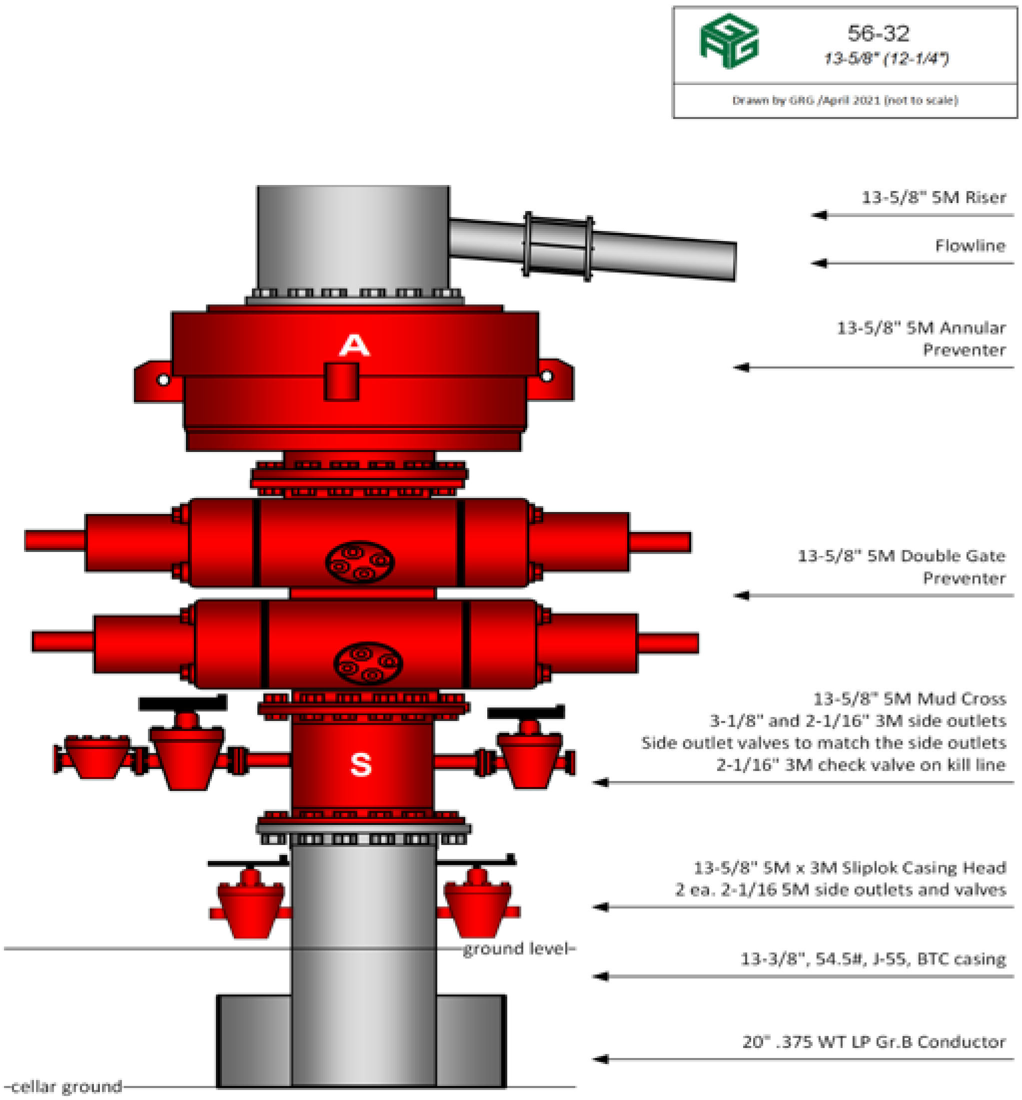


Figure 15 : BOPE 13-5/8 in. for drilling 12-1/4 in. hole.

6.3.4. 12-1/4 in. Bit, Hydraulics Program and BHA

Three bits were used to drill 12-1/4 in. hole section and Table 10 indicates some of the bit parameters.

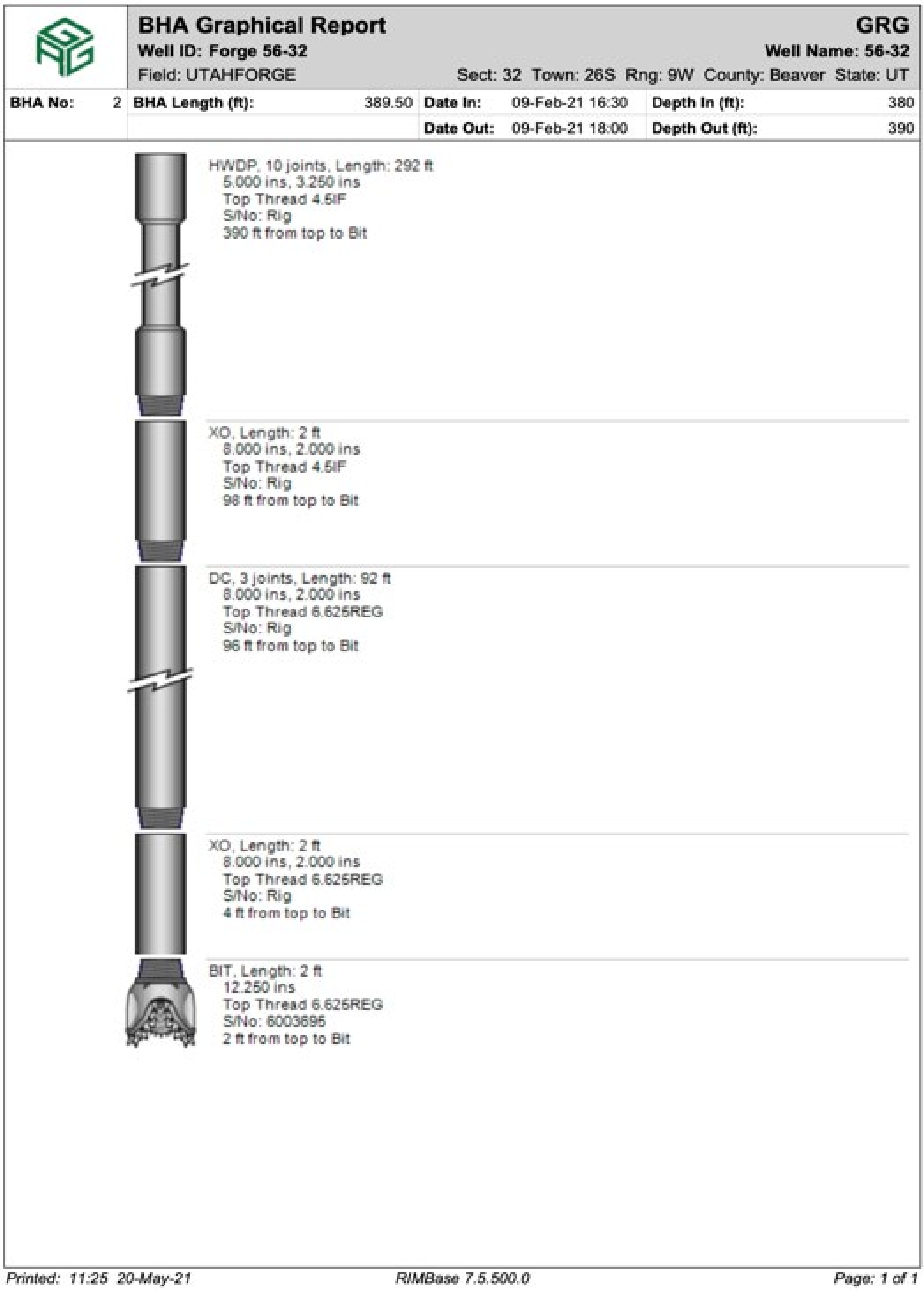
Table 10: 12-1/4 in. bit parameters.

Bit #/Run	Hole made (ft)	Bit Size (in.)	IADC Code	Ave. WOB (klb.)	Ave. RPM	Jet Size (32nd)	Ave. flow rate (gpm)	Ave. ROP (fph)
2/1	10	12-1/4 in.	111	12	153	16 16 16	403	90
3/1	2,919	12-1/4 in.	M423	32	270	22 22 22 22 22 22 22 11	830	301
4/1	191	12-1/4 in.	M433	35	290	22 22 22 22 22 22 11 11	830	73.5

BHAs used in 12-1/4 in. hole section is listed below (Table 11).

Table 11: BHAs used to drill 12-1/4 in. hole section

BHA #	Depth In (ft)	Depth Out (ft)	Drilled Distance (ft.)	BHA Length (ft)	Remarks
2	380	390	10	389.5	Drilled out cement, float shoe and 10 ft on new hole.
3	390	3,309	2,919	1,092	Bit cored.
4	3,309	3,500	191	1,079	-



BHA Graphical Report GRG

Well ID: Forge 56-32 **Well Name: 56-32**

Field: UTAHFORGE Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	2	BHA Length (ft):	389.50	Date In:	09-Feb-21 16:30	Depth In (ft):	380
				Date Out:	09-Feb-21 18:00	Depth Out (ft):	390

HWDP, 10 joints, Length: 292 ft
5.000 ins, 3.250 ins
Top Thread 4.5IF
S/No: Rig
390 ft from top to Bit

XO, Length: 2 ft
8.000 ins, 2.000 ins
Top Thread 4.5IF
S/No: Rig
98 ft from top to Bit

DC, 3 joints, Length: 92 ft
8.000 ins, 2.000 ins
Top Thread 6.625REG
S/No: Rig
96 ft from top to Bit

XO, Length: 2 ft
8.000 ins, 2.000 ins
Top Thread 6.625REG
S/No: Rig
4 ft from top to Bit

BIT, Length: 2 ft
12.250 ins
Top Thread 6.625REG
S/No: 6003696
2 ft from top to Bit

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Figure 16: BHA # 2 used with bit # 2

BHA Graphical Report GRG

Well ID: Forge 56-32 **Well Name: 56-32**

Field: UTAHFORGE Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	3	BHA Length (ft):	1,091.56	Date In:	09-Feb-21 16:30	Depth In (ft):	390
				Date Out:	10-Feb-21 00:00	Depth Out (ft):	3,308

HWDP, 24 joints, Length: 730 ft
5.000 ins, 3.250 ins
Top Thread 4.5IF
S/No: RIG
1,092 ft from top to Bit

XO, Length: 3 ft
8.000 ins, 3.000 ins
Top Thread 4.5IF
S/No: RIG

DC, 9 joints, Length: 274 ft
8.000 ins, 3.000 ins
Top Thread 6.625REG
S/No: RIG
358 ft from top to Bit

SHOCK, Length: 13 ft
8.063 ins, 3.875 ins
Top Thread 6.625REG
S/No: 02/11/20

MONEL, Length: 29 ft
7.875 ins, 3.250 ins
Top Thread 6.625REG
S/No: DR6020
72 ft from top to Bit

STAB, Length: 5 ft
8.000 ins, 3.000 ins
Top Thread 6.625REG
NM STAB

XO, Length: 4 ft
8.125 ins, 3.750 ins
Top Thread 6.625REG
NBUBHO

MMTR, Length: 33 ft
8.000 ins
Top Thread 6.625REG
S/No: ML010
34 ft from top to Bit

BIT, Length: 1 ft
12.250 ins
Top Thread 6.625REG
Bit cored
S/No: A266974
1 ft from top to Bit

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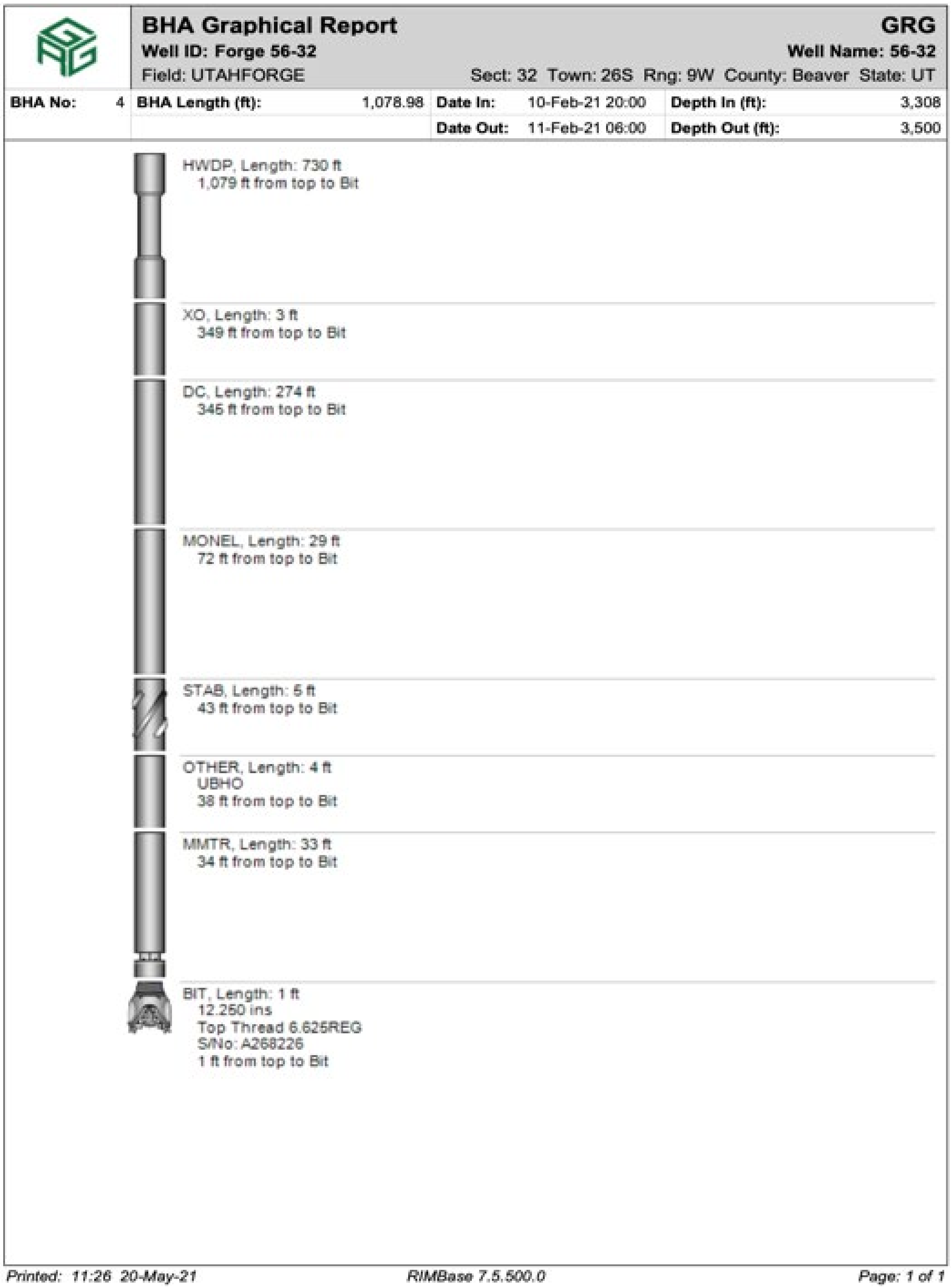
Figure 17: BHA # 3 used with bit # 3



BHA Graphical Report — GRG

Well ID: Forge 56-32 — **Well Name: 56-32**

Field: UTAHFORGE — Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No: 4	**BHA Length (ft):**	1,078.98	**Date In:**	10-Feb-21 20:00	**Depth In (ft):**	3,308
			Date Out:	11-Feb-21 06:00	**Depth Out (ft):**	3,500

HWDP, Length: 730 ft
1,079 ft from top to Bit

XO, Length: 3 ft
349 ft from top to Bit

DC, Length: 274 ft
346 ft from top to Bit

MONEL, Length: 29 ft
72 ft from top to Bit

STAB, Length: 5 ft
43 ft from top to Bit

OTHER, Length: 4 ft
UBHO
38 ft from top to Bit

MMTR, Length: 33 ft
34 ft from top to Bit

BIT, Length: 1 ft
12.250 ins
Top Thread 6.625REG
S/No: A268226
1 ft from top to Bit

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Figure 18: BHA # 4 used with bit # 4

6.3.5. 12-1/4 in. Drilling Fluids

Planned basic drilling parameters and the design of the mud system for the 12-1/4 in. drilling section are shown in Table 12 and the average parameters used are shown in Table 13. The mud system was designed as a lightly dispersed clay-based mud system with a weight between 8.6 and 9.5 ppg, adding gel as needed to maintain adequate viscosity for good hole cleaning.

Table 12: Planned fluids parameters for 12-1/4 in. hole section

Hole Size	12-1/4 in.
Casing Size	9-5/8 in.
Mud Type	HT treated Gel/Water/Polymer System
Mud Weight (ppg)	8.6 – 9.5
Viscosity (sec)	45-60
Filtrate (ML)	< 12
Total Mud Volume	1,000 bbls (500 bbls surface volume)
Directional Program	NA – Vertical Hole
Formations	Surface Alluvium, Tuff, Top of Granite
Interval BHT	< 200ºF
Lightly dispersed Clay-based mud HT system; drill 12-1/4 in. hole, adding Gel as needed to maintain adequate viscosity for good hole cleaning (YP 15-25). Use Bentonite/LCM pills and Polyvis (PHPA) to sweep hole; thin mud with Desco CF/HT Thin as needed. Maintain mud weight to control any artesian influx, if encountered, and add 2ppb Micro C for Wellbore Strengthening. Use DMA/PAC Polymer for desired fluid loss control, and TORKease/Walnut to reduce torque and drag; maintain pH of 9.5-10.5 with Caustic Soda/Lime. If encountered, control lost circulation with conventional LCM pills and drill cuttings. Run and cement 9 5/8 in. casing	

Table 13: Average fluid properties for 12-1/4 in. section

Fluid Parameters (spud)	Unit	Min	Max	Ave
Mud Weight	ppg	8.6	8.9	8.8

pH		8	10	10
API Fluid Loss (Filtrate)	cc/30 sec.	7	7.2	7.2
Plastic Viscosity	cP	15	15	15
Yield Point	$lb/100ft^2$	16	16	16

6.3.6. 9-5/8 in. Casing and Cementing

The 9-5/8 in., 36 ppf, J-55 casing was run on 11 February, with the shoe set at 3,494 ft. and cemented. The cement report is shown in Table 14 and pump schedule in Figure 19. No top jobs were needed. After 6 hours waiting on cement, preparations for drilling the next drilling section were made.

Table 14: Cement job report for 9-5/8 in. casing.

Cement Job Information			
Start Date/Time:	11-Feb-21 21:30	Wellbore:	Original Wellbore
Job Type:	PRIMARY	String OD (ins):	9.625
Well Section:	INT1	String Type:	FULL
Cementing Co:	Resource	Cementing Engineer:	Alex

Primary Job Detail	Volume (bbls)	Pump Time	Rate (bbls/min)	Pressure (psi)
Conditioning Data:		2	2.0	2,600
Cement Data:	308.0	39	8.0	250
Displacement Data:	264.0	53	5.0	1,000
Calc. Displacement Vol:	270.0			

☐ Reciprocate Pipe?	☑ Batch Mix?	☑ Bump Plug?	Bump Pressure:	1,500
Returns to Surface: FULL		☑ Cement at Surface?	Volume (bbls):	34.0
Calc Top of Cement (ft): 0		Excess (%): 50.00%	Avg. Hole Size (ins):	12.250

Slurry Information

Type	Density	Yield	Sacks	Volume	Rate	Additives
OTHER	13.40	1.64	1030	308.0	8.0	RC Therma Lite G1

Post Job Information

Liner Top Test (lbs/gal):		Job Success?	Yes
Actual Top of Cmt (ft):		CBL Bond Quality:	

Misc. Comments:

1) Hold pre-jog safety meeting.
2) Pump 2 BBL of Fresh Water to Fill Lines
3) Pressure test surface lines to 2,500 psi
4) Pump 10 BBL of Fresh Water Spacer @ 6-8 BPM
5) Pump 20 BBL of RC Mud Clean Spacer @ 6-8 BPM
6) Pump 30 BBL of 10.5ppg Sepiolite Spacer @ 6-8 BPM
7) Pump 5 BBL of Fresh Water Spacer @ 6-8 BPM
8) Pump 13 BBL of Sodium Silicate Spacer @ 2-3 BPM
9) Pump 5 BBL of Fresh Water Spacer @ 6-8 BPM
10) Pump 300.8 BBL of 13.4 ppg RC ThermaLite HT @ 6-8 BPM
11) Shut Down, Release Top Plug
12) Displace Cement with 270 BBL of Drilling MUD @ 5 - 8 BPM – Monitor Pressure and returns.
13) Slow down last 20 BBL to 2BPM
14) Slow Down Last 10 BBL to 1BPM to BUMP PLUG.
15) Shut Down, Check Floats, CIP

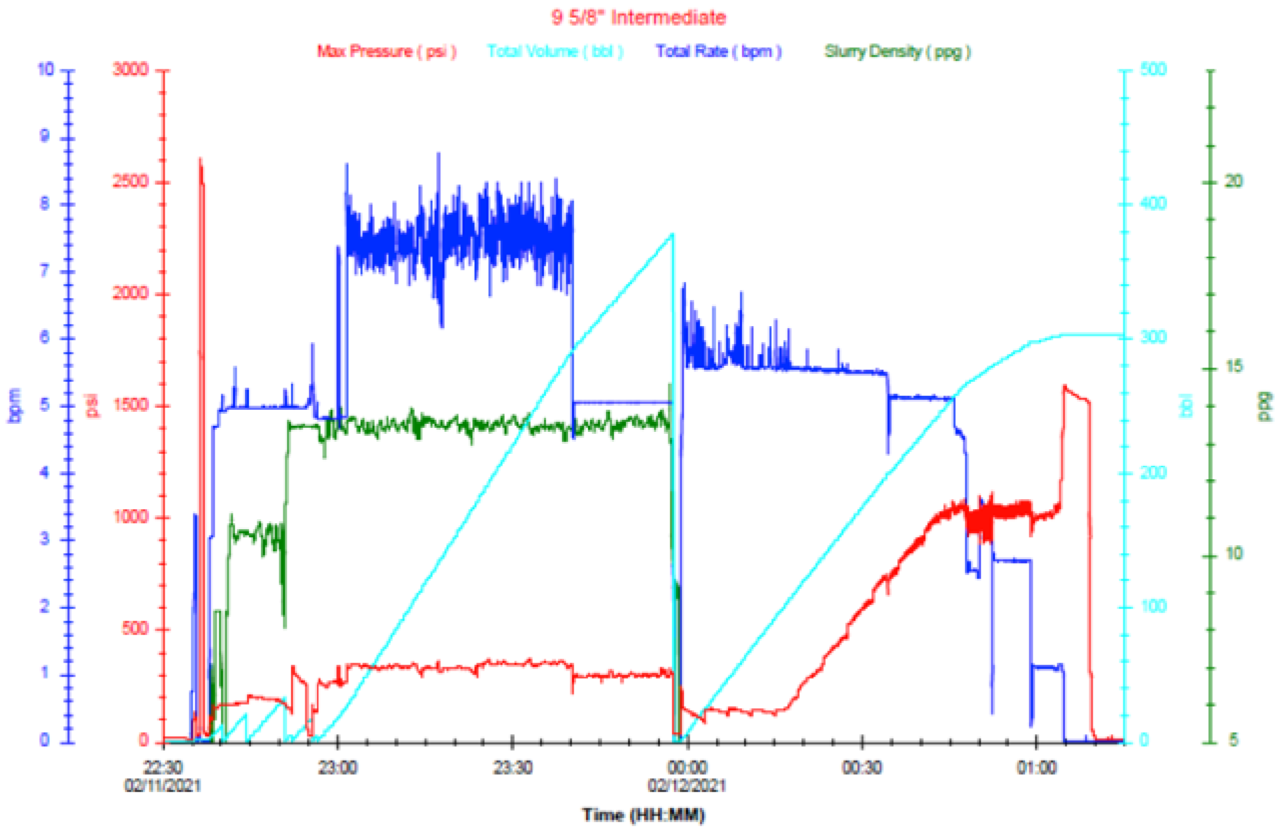


Figure 19: 9-5/8 in. intermediate casing cement pressure chart

6.4. 8-3/4 in. Hole to 9,105 ft., 5-1/2 in. Liner

6.4.1. 8-3/4 in. Objectives

The drilling objectives for the 12-1/4 in. section were:

- Drill the cement inside the 9-5/8 in. shoe track (±80 ft) and 5,900 ft of new hole from the 9-5/8 in. casing shoe to 7,500 ft. with 6 ea. bit trips
- Continue drilling 8-3/4 in. hole to ±9,000 ft. using a mud hammer
- Maintain verticality within 2° and stabilize wellbore hazards
- Penetrate the reservoir test section
- Drill fast to reduce wellbore exposure to the drilling fluid
- Install fiber optic cable on the OD of the casing from 7,500 ft. back to surface

All of these objectives were achieved, though in the cementing of the 5-1/2 in. with fiber optic casing, the string was broken, so it is not able to serve its desired function, discussed later.

6.4.2. 8-3/4 in. Summary

The drilling of the 8-3/4 in. hole commenced on 12 February, and total depth of 9,145 ft. was reached on 27 February. Twelve 8-3/4 in. bits were required due to the hardness of the formation on bit life. In some sections of the well, the inclination was as high as 6°, particularly around 5,600 ft., but it was corrected by using directional tools and at TD, the final inclination was 3°. Geophysical open hole logs were run by Schlumberger in the 8-3/4 in. section, 5-1/2 in. blank casing was cemented to 9,105 ft, discussed in a separate section.

6.4.3. 8-3/4 in. Surface Equipment

The 9-5/8 in. casing was cut off and the 8-3/4 in. surface BOPE equipment used was the same as used for the 12-1/4 in. section, using a 13-5/8 in. 5M x 3M Sliplock Casing Head, for fast assembly (Figure 20). The annular preventer and pipe rams were tested prior to running in the hole. A FIT was performed after drilling 5 ft. of new formation, giving a maximum allowable mud weight of 19.23 ppg.

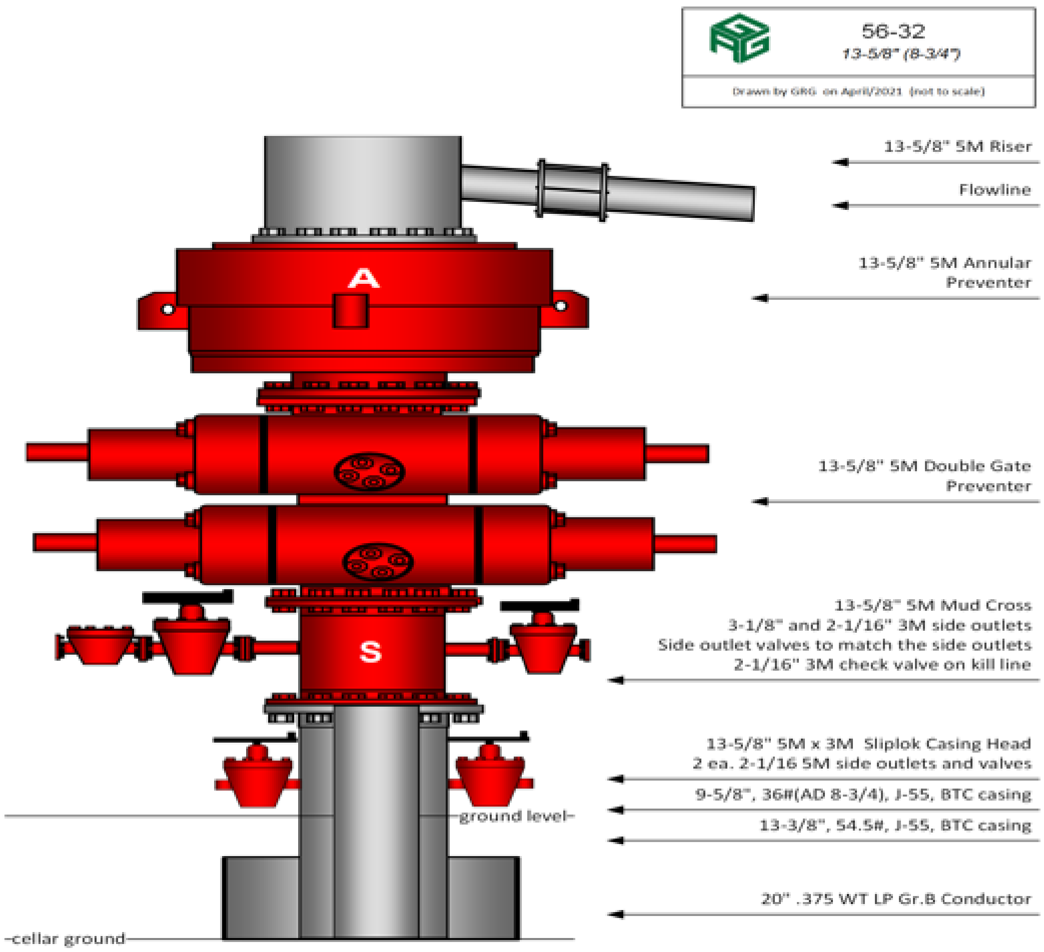


Figure 20: BOPE stack for drilling 8-3/4 in. hole

6.4.4. 8-3/4 in. Bits, Hydraulics Program and BHA

In the 8-3/4 in. section, the primary formation was granodiorite, and a selection of bits were used through the section to test their performance. After the 5-1/2 in. casing was run, a 4-3/4 in. bit was run to clean out the cement inside casing. The bits used in this section is captured in Table 15.

Table 15: Bits used in drilling 8-3/4 in. hole section

Bit #/Run	Hole made (ft)	Bit Size (in.)	IADC Code	Ave. WOB (klb.)	Ave. RPM	Jet Size (32nd)	Ave. flow rate (gpm)	Ave. ROP (fph)
5/1	6	8.75	117	32	155	20 20 20	409	7.5
6/1	1,089	8.75	M433	40	227	14 14 14 14 13 13 13	700	37.7
7/1	548	8.75	627	50	205	20 20 20	680	20.9
8/1	467	8.75	M333	50	205	14 14 14 14 14 14	700	30.1
9/1	389	8.75	M333	50	200	14 14 14 13 13 13	687	26.3
10/1	1,209	8.75	M433	46	198	13 13 13 13 12 12 12	677	23.2
11/1	412	8.75	M333	46	202	13 13 13 13 14 14 14	685	85.8
11/2	35	8.75	M333	46	194	14 14 14 13 13 13	577	31.8
12/1	8	8.75	Hammer E6 Bit	20	153	-	500	10
12/2	4	8.75	Hammer E6 Bit	32	164	-	553	5
13/1	1,233	8.75	M333	50	190	14 14 14 13 13 13	667	33.3
14/1	245	8.75	M433	45	183	14 14 14 14 11 11 11 11	644	76.7

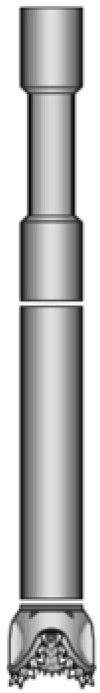
BHAs used in 8-3/4 in. hole section can be seen in Figure 21 to Figure 31.

BHA Graphical Report — **GRG**

Well ID: Forge 56-32 — **Well Name: 56-32**

Field: UTAHFORGE — Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	5	**BHA Length (ft):**	762.86	**Date In:**	12-Feb-21 13:00	**Depth In (ft):**	3,500
				Date Out:	12-Feb-21 14:30	**Depth Out (ft):**	3,506



HWDP, Length: 731 ft
S/No: Rig
763 ft from top to Bit

DC, Length: 31 ft
6.000 ins
S/No: Rig
32 ft from top to Bit

BIT, Length: 1 ft
8.750 ins
Top Thread 4.5REG
S/No: 5258442
1 ft from top to Bit

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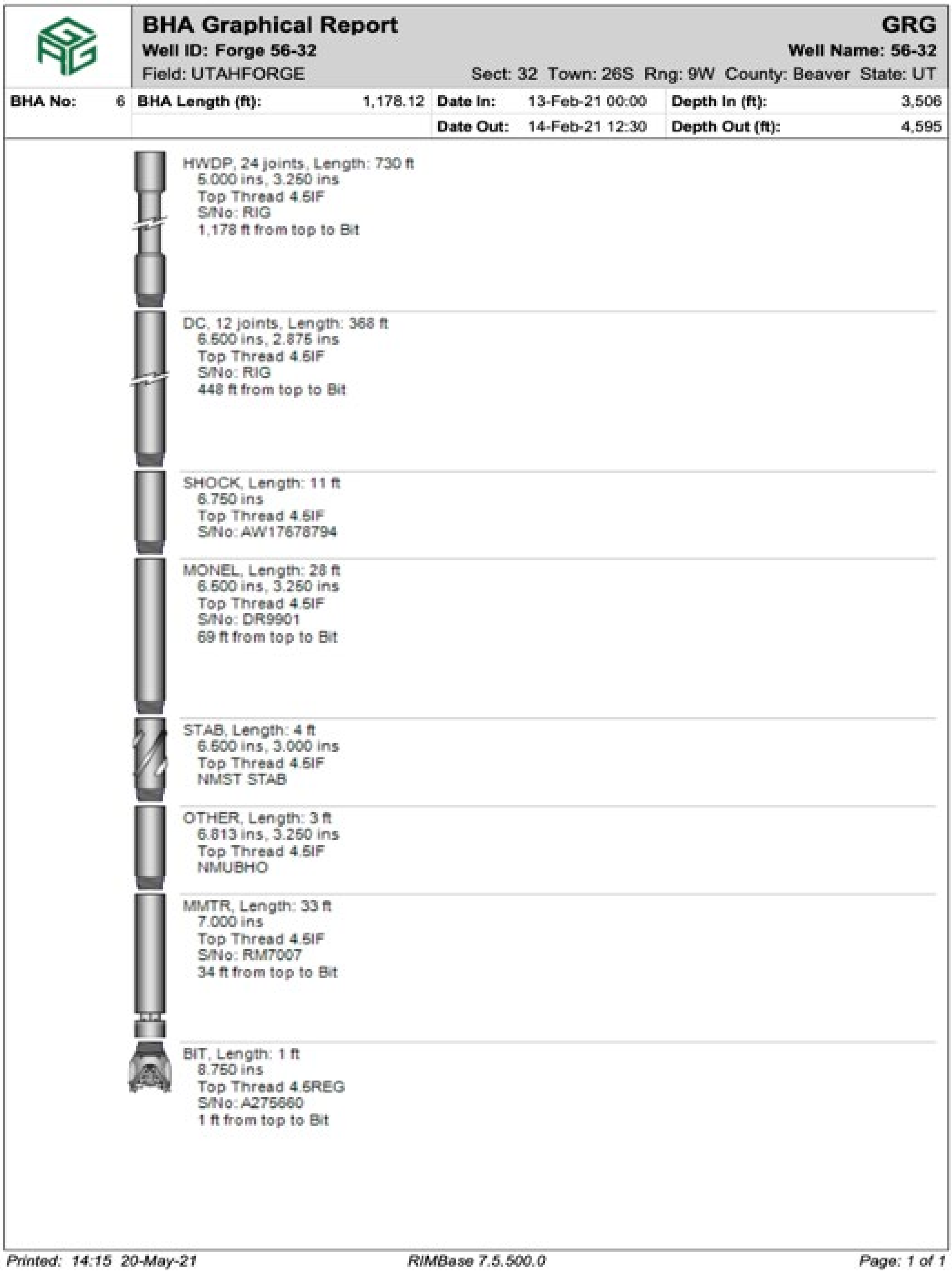
Figure 21: 8-3/4 in. BHA #5 used with bit #5



BHA Graphical Report GRG

Well ID: Forge 56-32 **Well Name: 56-32**

Field: UTAHFORGE Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	6	BHA Length (ft):	1,178.12	Date In:	13-Feb-21 00:00	Depth In (ft):	3,506
				Date Out:	14-Feb-21 12:30	Depth Out (ft):	4,595

HWDP, 24 joints, Length: 730 ft
5.000 ins, 3.250 ins
Top Thread 4.5IF
S/No: RIG
1,178 ft from top to Bit

DC, 12 joints, Length: 368 ft
6.500 ins, 2.875 ins
Top Thread 4.5IF
S/No: RIG
448 ft from top to Bit

SHOCK, Length: 11 ft
6.750 ins
Top Thread 4.5IF
S/No: AW17678794

MONEL, Length: 28 ft
6.500 ins, 3.250 ins
Top Thread 4.5IF
S/No: DR9901
69 ft from top to Bit

STAB, Length: 4 ft
6.500 ins, 3.000 ins
Top Thread 4.5IF
NMST STAB

OTHER, Length: 3 ft
6.813 ins, 3.250 ins
Top Thread 4.5IF
NMUBHO

MMTR, Length: 33 ft
7.000 ins
Top Thread 4.5IF
S/No: RM7007
34 ft from top to Bit

BIT, Length: 1 ft
8.750 ins
Top Thread 4.5REG
S/No: A275660
1 ft from top to Bit

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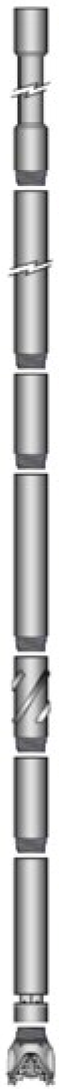
Figure 22: 8-3/4 in. BHA #6 used with bit #6

BHA Graphical Report **GRG**

Well ID: Forge 56-32 **Well Name: 56-32**

Field: UTAHFORGE Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	7	BHA Length (ft):	1,178.54	Date In:	14-Feb-21 19:30	Depth In (ft):	495
				Date Out:	16-Feb-21 00:16	Depth Out (ft):	5,143



HWDP, 24 joints, Length: 730 ft
5.000 ins, 3.250 ins
Top Thread 4.5IF
S/No: RIG
1,179 ft from top to Bit

DC, 12 joints, Length: 368 ft
6.500 ins, 2.875 ins
Top Thread 4.5IF
S/No: RIG
448 ft from top to Bit

SH/SUB, Length: 11 ft
6.750 ins
Top Thread 4.5IF
S/No: 3009389

MONEL, Length: 28 ft
6.500 ins, 3.250 ins
Top Thread 4.5IF
S/No: DR9901
69 ft from top to Bit

STAB, Length: 5 ft
6.500 ins, 3.000 ins
Top Thread 4.5IF
NMSTAB

XO, Length: 3 ft
6.813 ins, 3.250 ins
Top Thread 4.5IF
NMUBHO

MMTR, Length: 33 ft
7.000 ins
Top Thread 4.5IF
S/No: RM7004
34 ft from top to Bit

BIT, Length: 1 ft
8.750 ins
Top Thread 4.5REG
S/No: 5865475-01
1 ft from top to Bit

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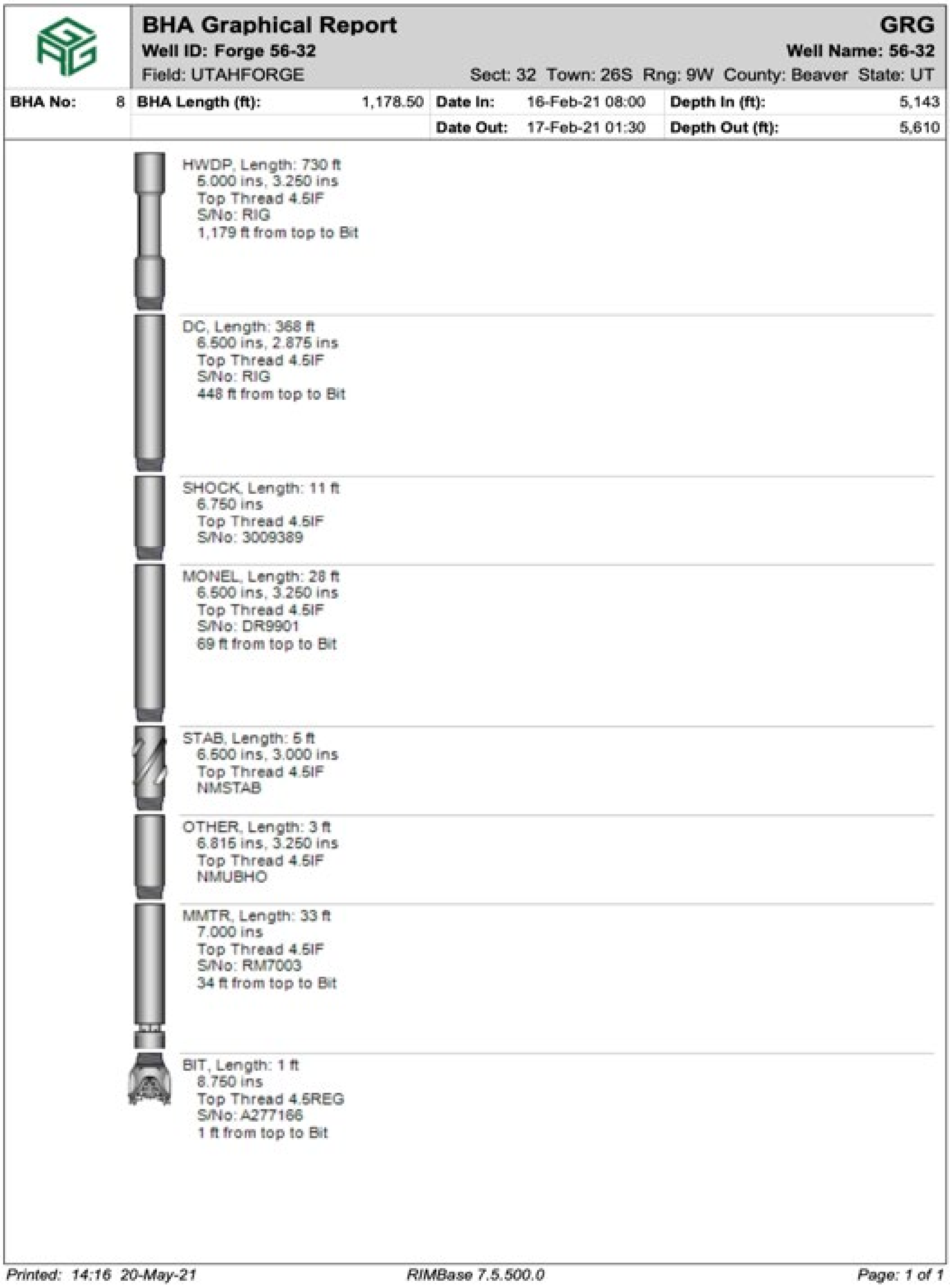
Figure 23: 8-3/4 in. BHA #7 used with bit #7



BHA Graphical Report GRG

Well ID: Forge 56-32 **Well Name: 56-32**

Field: UTAHFORGE Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	8	BHA Length (ft):	1,178.50	Date In:	16-Feb-21 08:00	Depth In (ft):	5,143
				Date Out:	17-Feb-21 01:30	Depth Out (ft):	5,610

HWDP, Length: 730 ft
5.000 ins, 3.250 ins
Top Thread 4.5IF
S/No: RIG
1,179 ft from top to Bit

DC, Length: 368 ft
6.500 ins, 2.875 ins
Top Thread 4.5IF
S/No: RIG
448 ft from top to Bit

SHOCK, Length: 11 ft
6.750 ins
Top Thread 4.5IF
S/No: 3009389

MONEL, Length: 28 ft
6.500 ins, 3.250 ins
Top Thread 4.5IF
S/No: DR9901
69 ft from top to Bit

STAB, Length: 5 ft
6.500 ins, 3.000 ins
Top Thread 4.5IF
NMSTAB

OTHER, Length: 3 ft
6.815 ins, 3.250 ins
Top Thread 4.5IF
NMUBHO

MMTR, Length: 33 ft
7.000 ins
Top Thread 4.5IF
S/No: RM7003
34 ft from top to Bit

BIT, Length: 1 ft
8.750 ins
Top Thread 4.5REG
S/No: A277166
1 ft from top to Bit

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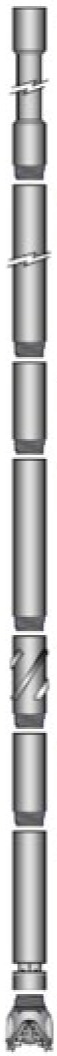
Figure 24: 8-3/4 in. BHA #8 used with bit #8

BHA Graphical Report GRG

Well ID: Forge 56-32 **Well Name: 56-32**

Field: UTAHFORGE Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	9	**BHA Length (ft):**	1,179.22	**Date In:**	17-Feb-21 09:00	**Depth In (ft):**	5,610
				Date Out:	18-Feb-21 01:30	**Depth Out (ft):**	5,999



HWDP, 24 joints, Length: 730 ft
5.000 ins, 3.250 ins
Top Thread 4.5IF
S/No: RIG
1,179 ft from top to Bit

DC, 12 joints, Length: 368 ft
6.500 ins, 2.875 ins
Top Thread 4.5IF
S/No: RIG
449 ft from top to Bit

SHOCK, Length: 11 ft
6.875 ins
Top Thread 4.5IF
S/No: 6750040

MONEL, Length: 28 ft
6.500 ins, 3.250 ins
Top Thread 4.5IF
S/No: DR9901
70 ft from top to Bit

STAB, Length: 5 ft
6.563 ins, 3.000 ins
Top Thread 4.5IF
NMSTAB

OTHER, Length: 3 ft
6.813 ins, 3.250 ins
Top Thread 4.5IF
NMUBHO

MMTR, Length: 33 ft
7.000 ins
Top Thread 4.5IF
S/No: RM7002
34 ft from top to Bit

BIT, Length: 1 ft
8.750 ins
Top Thread 4.5REG
S/No: A271436
1 ft from top to Bit

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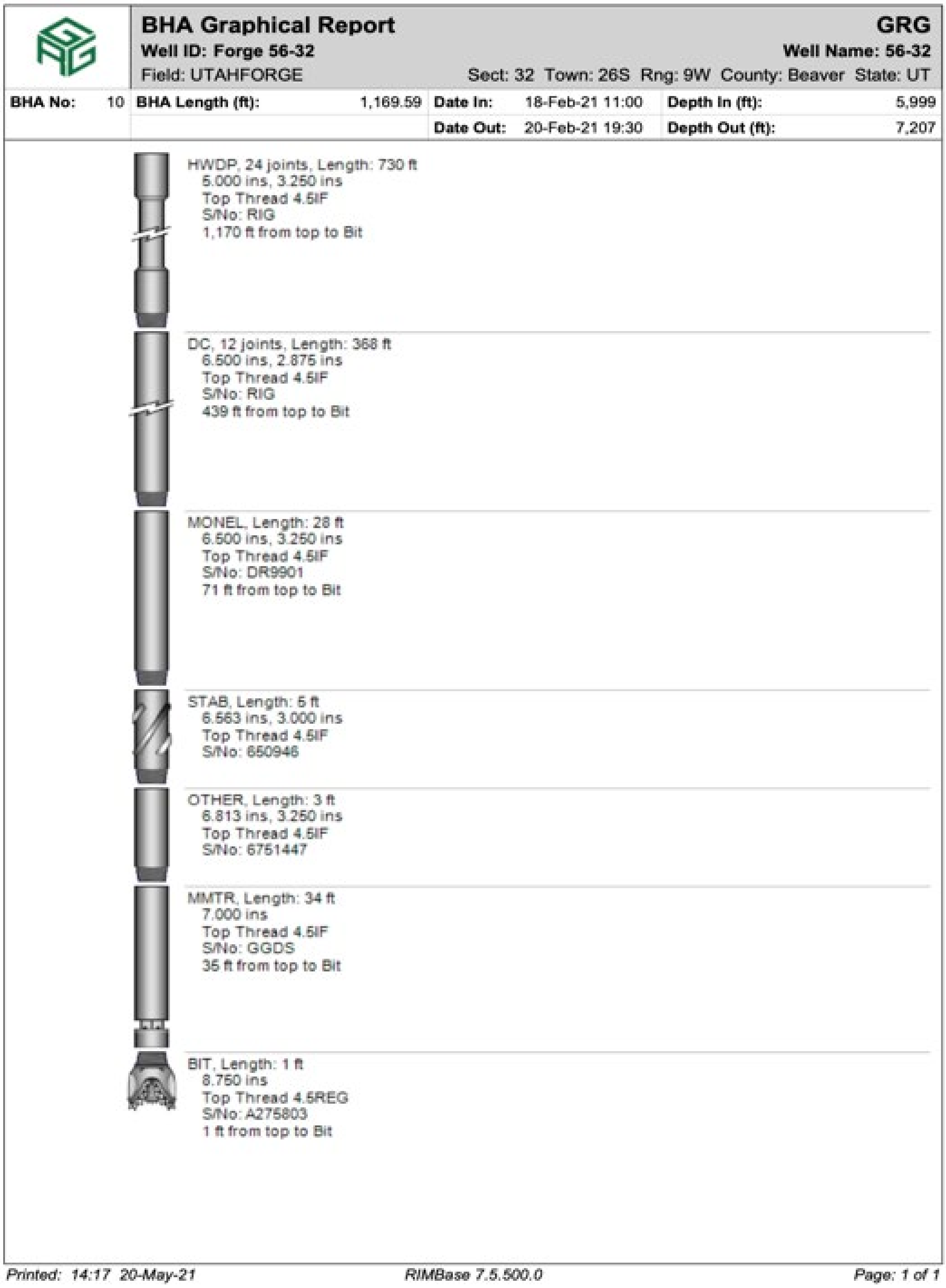
Figure 25: 8-3/4 in. BHA #9 used with bit #9



BHA Graphical Report — **GRG**

Well ID: Forge 56-32 — **Well Name: 56-32**

Field: UTAHFORGE — Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	10	BHA Length (ft):	1,169.59	Date In:	18-Feb-21 11:00	Depth In (ft):	5,999
				Date Out:	20-Feb-21 19:30	Depth Out (ft):	7,207

HWDP, 24 joints, Length: 730 ft
5.000 ins, 3.250 ins
Top Thread 4.5IF
S/No: RIG
1,170 ft from top to Bit

DC, 12 joints, Length: 368 ft
6.500 ins, 2.875 ins
Top Thread 4.5IF
S/No: RIG
439 ft from top to Bit

MONEL, Length: 28 ft
6.500 ins, 3.250 ins
Top Thread 4.5IF
S/No: DR9901
71 ft from top to Bit

STAB, Length: 5 ft
6.563 ins, 3.000 ins
Top Thread 4.5IF
S/No: 650946

OTHER, Length: 3 ft
6.813 ins, 3.250 ins
Top Thread 4.5IF
S/No: 6751447

MMTR, Length: 34 ft
7.000 ins
Top Thread 4.5IF
S/No: GGDS
35 ft from top to Bit

BIT, Length: 1 ft
8.750 ins
Top Thread 4.5REG
S/No: A275803
1 ft from top to Bit

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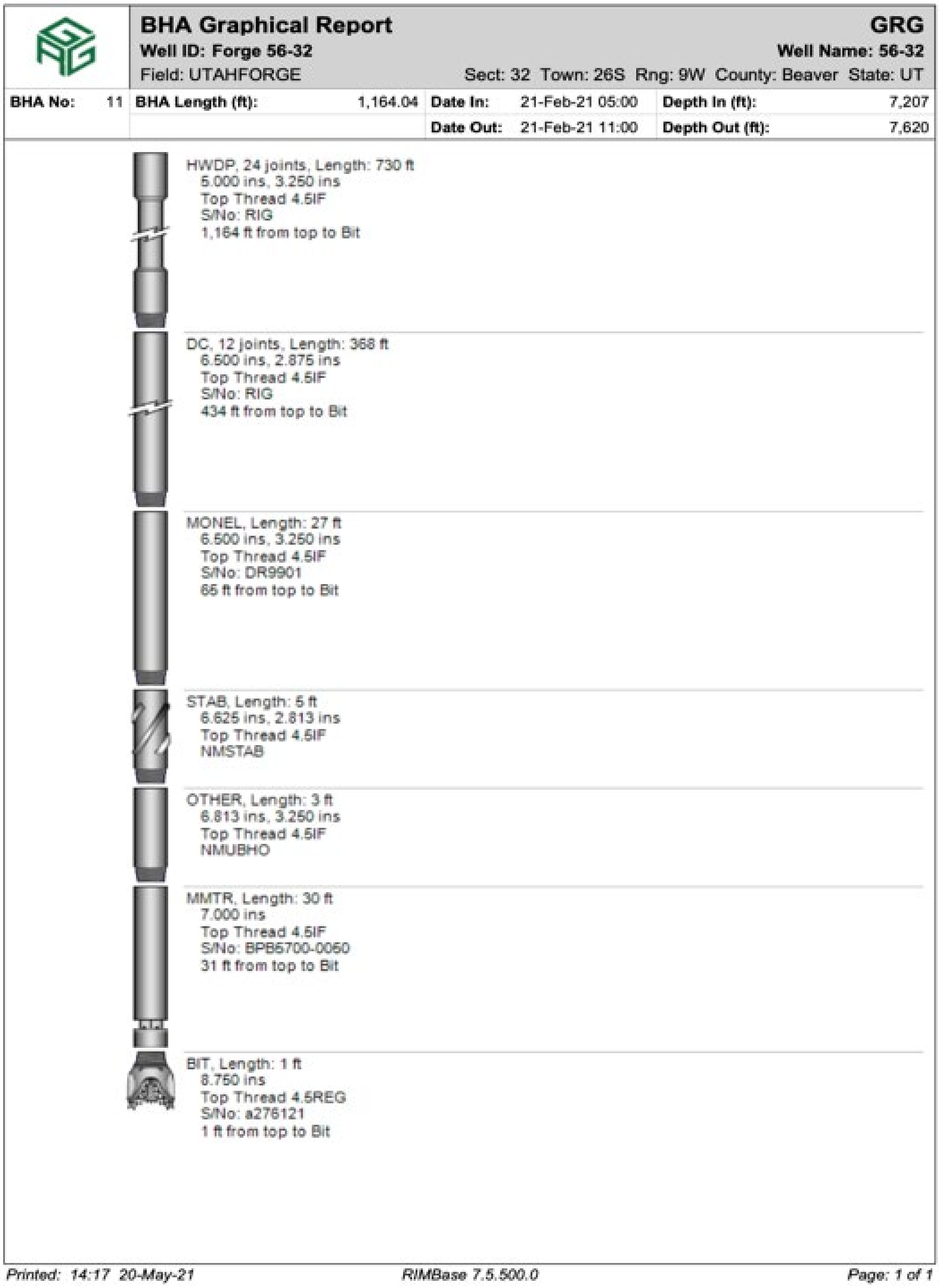
Figure 26: 8-3/4 in. BHA #10 used with bit #10



BHA Graphical Report **GRG**

Well ID: Forge 56-32 **Well Name: 56-32**

Field: UTAHFORGE Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	11	BHA Length (ft):	1,164.04	Date In:	21-Feb-21 05:00	Depth In (ft):	7,207
				Date Out:	21-Feb-21 11:00	Depth Out (ft):	7,620

HWDP, 24 joints, Length: 730 ft
5.000 ins, 3.250 ins
Top Thread 4.5IF
S/No: RIG
1,164 ft from top to Bit

DC, 12 joints, Length: 368 ft
6.500 ins, 2.875 ins
Top Thread 4.5IF
S/No: RIG
434 ft from top to Bit

MONEL, Length: 27 ft
6.500 ins, 3.250 ins
Top Thread 4.5IF
S/No: DR9901
65 ft from top to Bit

STAB, Length: 5 ft
6.625 ins, 2.813 ins
Top Thread 4.5IF
NMSTAB

OTHER, Length: 3 ft
6.813 ins, 3.250 ins
Top Thread 4.5IF
NMUBHO

MMTR, Length: 30 ft
7.000 ins
Top Thread 4.5IF
S/No: BPB5700-0050
31 ft from top to Bit

BIT, Length: 1 ft
8.750 ins
Top Thread 4.5REG
S/No: a276121
1 ft from top to Bit

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Figure 27: 8-3/4 in. BHA #11 used with bit #11

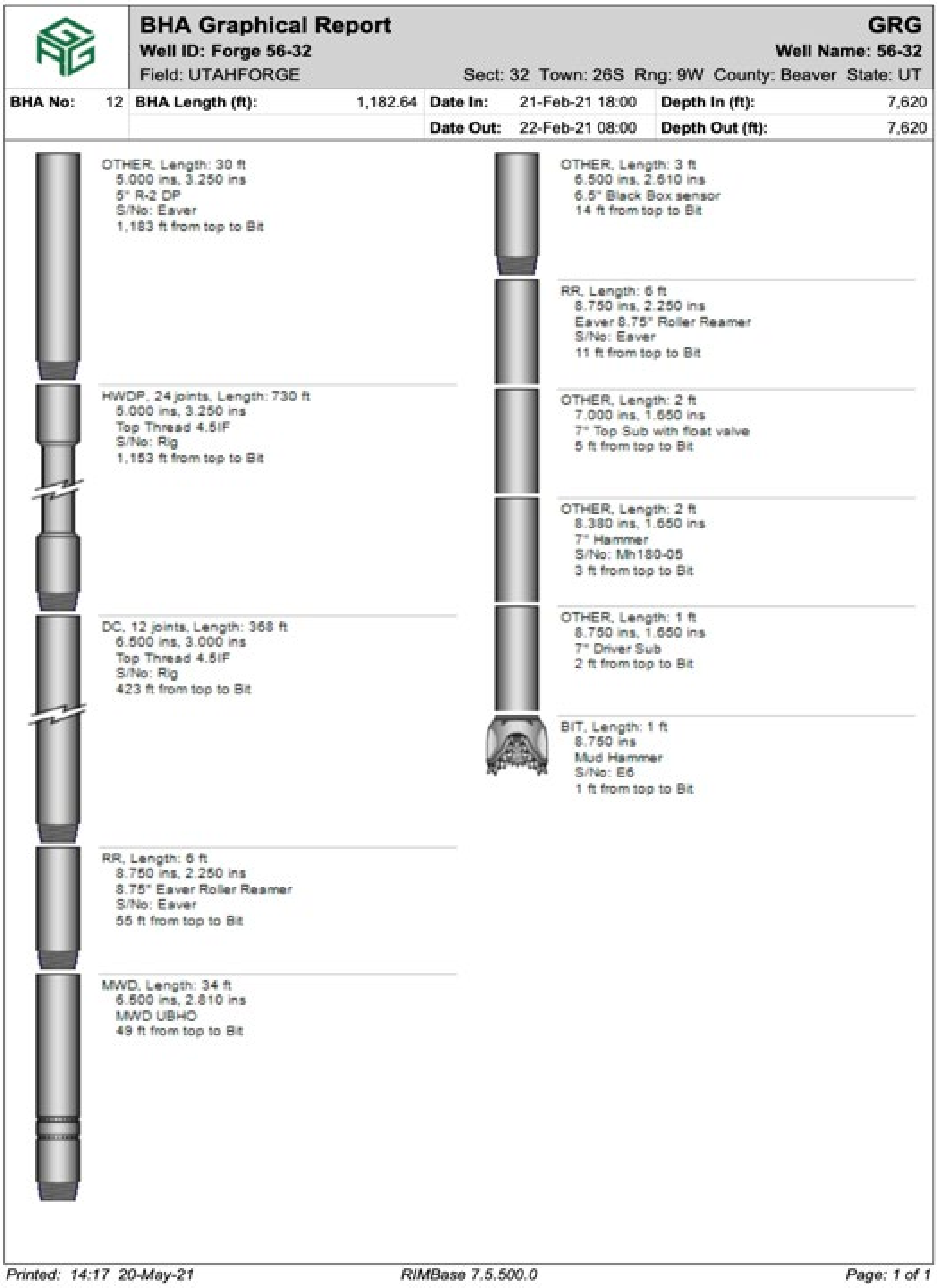


Figure 28: 8-3/4 in. BHA #12 used with bit #12

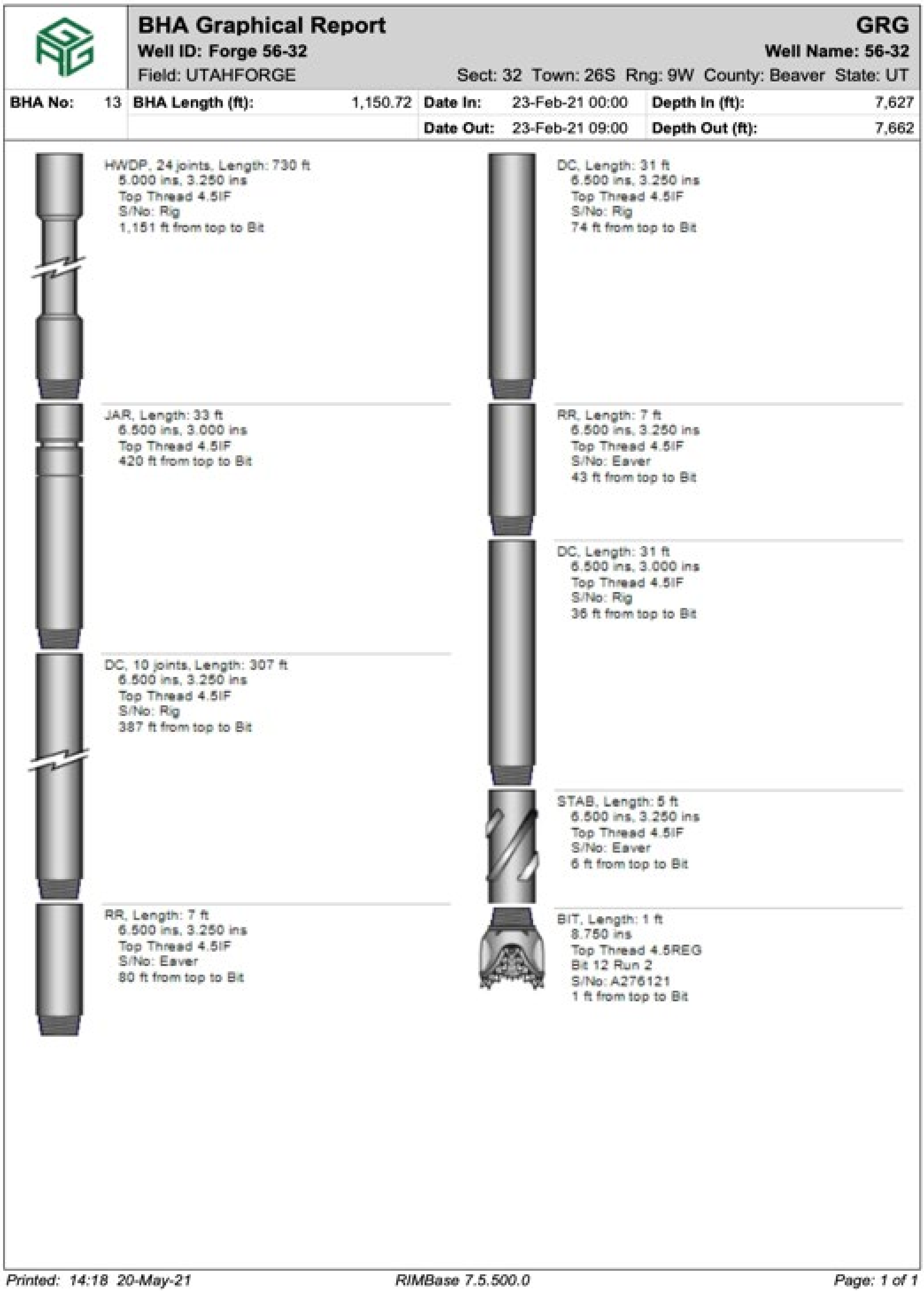


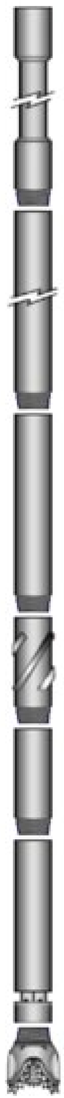
Figure 29: 8-3/4 in. BHA #13 used with bit #11

BHA Graphical Report GRG

Well ID: Forge 56-32 **Well Name: 56-32**

Field: UTAHFORGE Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	14	**BHA Length (ft):**	1,227.95	**Date In:**	24-Feb-21 07:30	**Depth In (ft):**	7,666
				Date Out:	26-Feb-21 03:00	**Depth Out (ft):**	8,900



HWDP, 24 joints, Length: 730 ft
5.000 ins, 3.250 ins
Top Thread 4.5IF
S/No: RIG
1,228 ft from top to Bit

DC, 12 joints, Length: 433 ft
6.500 ins, 2.875 ins
Top Thread 4.5IF
S/No: RIG
498 ft from top to Bit

MONEL, Length: 27 ft
6.500 ins, 3.250 ins
Top Thread 4.5IF
S/No: DR26583
65 ft from top to Bit

STAB, Length: 3 ft
6.500 ins, 2.813 ins
Top Thread 4.5IF
NMSTAB

OTHER, Length: 3 ft
6.813 ins, 3.250 ins
Top Thread 4.5IF
NMUBHO

MMTR, Length: 30 ft
7.000 ins
Top Thread 4.5IF
S/No: BPB6700-0042
31 ft from top to Bit

BIT, Length: 1 ft
8.750 ins
Top Thread 4.5REG
S/No: A271437
1 ft from top to Bit

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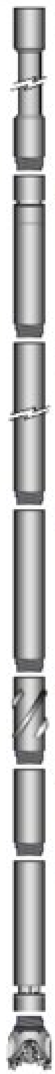
Figure 30: 8-3/4 in. BHA #14 used with bit #13

BHA Graphical Report **GRG**

Well ID: Forge 56-32 **Well Name: 56-32**

Field: UTAHFORGE Sect: 32 Town: 26S Rng: 9W County: Beaver State: UT

BHA No:	15	**BHA Length (ft):**	1,202.18	**Date In:**	26-Feb-21 14:00	**Depth In (ft):**	8,900
				Date Out:	27-Feb-21 14:00	**Depth Out (ft):**	9,145



HWDP, 24 joints, Length: 730 ft
5.000 ins, 3.250 ins
Top Thread 4.5IF
S/No: RIG
1,202 ft from top to Bit

JAR, Length: 34 ft
6.500 ins, 3.000 ins
Top Thread 4FH
S/No: USKW13554349
472 ft from top to Bit

DC, 12 joints, Length: 368 ft
6.500 ins, 2.875 ins
Top Thread 4.5IF
S/No: RIG
438 ft from top to Bit

MONEL, Length: 27 ft
6.500 ins, 3.250 ins
Top Thread 4.5IF
S/No: DR26583
70 ft from top to Bit

STAB, Length: 5 ft
6.500 ins, 2.813 ins
Top Thread 4.5IF
NMSTAB

OTHER, Length: 3 ft
6.813 ins, 3.250 ins
Top Thread 4.5IF
NMUBHO

MMTR, Length: 34 ft
7.000 ins
Top Thread 4.5IF
DISCOVERY
S/No: 700DDS025
35 ft from top to Bit

BIT, Length: 1 ft
8.750 ins
Top Thread 4.5REG
TKC813
S/No: A276071
1 ft from top to Bit

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Figure 31: 8-3/4 in. BHA #15 used with bit #14

6.4.5. 8-3/4 in. Drilling Fluids

Planned basic drilling parameters and the design of the mud system for the 8-3/4 in. drilling sections are shown in Table 16 and the average parameters used are shown in Table 17. The mud system was designed as a lightly dispersed clay-based mud system with a weight between 8.6 and 9.5 ppg, adding gel as needed to maintain adequate viscosity for good hole cleaning.

Table 16: Fluid parameters planned for 8-3/4 in.

Hole Size	17-1/2 in.
Casing Size	13-3/8 in.
Mud Type	Lime/Gel/Water System
Mud Weight (ppg)	8.6 – 9.2
Viscosity (sec)	50-60+
Filtrate (ML)	< 20
Total Mud Volume	1,200 bbls (500 bbls surface volume)
Directional Program	NA – Vertical Hole
Formations	Granite-Gneiss
Interval BHT	~ 365ºF
Continue drilling 8-3/4 in. hole. Use viscous polymer sweeps consisting of Xanthan Gum/Polyvis and SinSweep regularly, to clean and stabilize the wellbore. IF severe lost circulation is encountered, consider drilling blind and/or using temperature degradable LCMs such as Micro C, Sawdust, Cottonseed Hulls, and AltaVert 102. Maintain pH of 11.0 with Caustic Soda, and TORKease to reduce torque and drag. Monitor corrosion rates onsite and treat any unacceptable rates with corrosion additives. Pump cold water as needed to control well and consider use of weighted brines for additional pressure control, if needed. Run and cement 5 ½ in. casing to 9,000	

Table 17: Average fluid properties for 8-3/4 in. section

Fluid Parameters (spud)	Unit	Min	Max	Ave
Mud Weight	ppg	8.7	8.7	8.7
pH		8	10	8.75
API Fluid Loss (Filtrate)	cc/30 sec.	13.3	18.2	15.75

Fluid Parameters (spud)	Unit	Min	Max	Ave
Plastic Viscosity	cP	12	22	17
Yield Point	lb/100ft^2	10	21	15.5

6.4.6. 5-1/2 in. Casing and Cementing

Upon reaching hole TD and cleaning hole, a side wall core was attempted (no recovery), and a suite of geophysical logs was run including a Triple Combo and gyro using through bit logging method, discussed in later section. The wellhead was prepped for casing running and the 5-1/2 in. 17 ppf L-80 casing was run with the Silixa fiber optic cable strapped to outside, setting the shoe at 9,105 ft.ft. in 21.5 hours (including 3 hours for circulation and cooling) on 1-2 March.

Cementing of 5-1/2 in. commenced on 13:00 h on 2 March. After pumping 537 bbls of cement, pressure started increasing rapidly from 500 psi to 1,800 psi. Continued to pump cement and shut down at a total volume of 620 bbl. of cement then shutdown, pump 2 bbls of water then drop top plug, to displace with displacement fluid while the casing was reciprocated. Only 27 bbls of displacement fluid were able to be pumped and displacement was shut down due to high pressure of approximately 6,200 psi that were at the limit of the casing capacity.

After finding that it would not be possible to displace cement out of the casing, it was decided to pump 160 bbls of fresh water into annular to clear any spacers to previous shoe and have the opportunity to pump a top squeeze to place cement between casings.

Primary and remedial cementing report are provided in Table 18 and Table 19 and Pump Schedules in Figure 32 and Figure 33. An investigation of the incident was made by a third party led by Dr. Glen Benge with the cementing service contractor. Their reports and conclusions are provided in Appendix 6.

Table 18: Primary cement job report for 5-1/2 in. casing

Cement Job Information			
Start Date/Time:	02-Mar-21 13:00	Wellbore:	Original Wellbore
Job Type:	PRIMARY	String OD (ins):	5.500
Well Section:	PROD	String Type:	FULL
Cementing Co:	Resource	Cementing Engineer:	

Primary Job Detail	Volume (bbls)	Pump Time	Rate (bbls/min)	Pressure (psi)
Conditioning Data:		21	5.0	237
Cement Data:	610.0	94	8.0	352
Displacement Data:	27.0	5	5.0	6,200
Calc. Displacement Vol:	27.0			

☑ Reciprocate Pipe?	☑ Batch Mix?	☐ Bump Plug?	Bump Pressure:
Returns to Surface: NONE		☐ Cement at Surface?	
Calc Top of Cement (ft): 3,200		Excess (%): 50.00%	Avg. Hole Size (ins): 8.750

Slurry Information						
Type	Density	Yield	Sacks	Volume	Rate	Additives
OTHER	13.60	1.73	1870	576.2		RC-ThermaLite 50/50 G8. Economical High Strength Low Density Blend

Post Job Information			
Liner Top Test (lbs/gal):		Job Success?	No
Actual Top of Cmt (ft):		CBL Bond Quality:	

Table 19: Secondary cement job for 5-1/2 in. casing

Cement Job Information			
Start Date/Time:	04-Mar-21 13:30	Wellbore:	Original Wellbore
Job Type:	SECONDARY	String OD (ins):	5.500
Well Section:	PROD	String Type:	FULL
Cementing Co:	Resource	Cementing Engineer:	ALEX

Secondary Job Details			
Remedial Type:	ZONE	No. of Attempts:	1
Breakdown Pressure (psi):		Breakdown Rate (bbls/min):	
Init. Injectn Pressure (psi):		Initial Injectn Rate(bbls/min):	
Final Injectn Pressure (psi):		Final Injectn Rate (bbls/min):	
Init. Shut In Pressure (psi):			
Hold Pressure (psi):		Hold Time:	
Bleed Back Volume (bbls):			

Slurry Information						
Type	Density	Yield	Sacks	Volume	Rate	Additives
SPACER	8.43			25.0	2.0	Pump 25 bbl of Fresh water to stablish pressure and rate
CLASSC	15.60			167.0	4.0	

Post Job Information			
Liner Top Test (lbs/gal):		Job Success?	Yes
Actual Top of Cmt (ft):	0	CBL Bond Quality:	
Misc. Comments:	Pumped 25 bbl of Fresh water to stablish pressure and rate. Pumped 167 bbls of 15.6ppg Cement at a rate from 4 BPM to 1 BPM Shut down, CIP At 22:00 Hours verified TOP of Cement and Cement was at surface,		

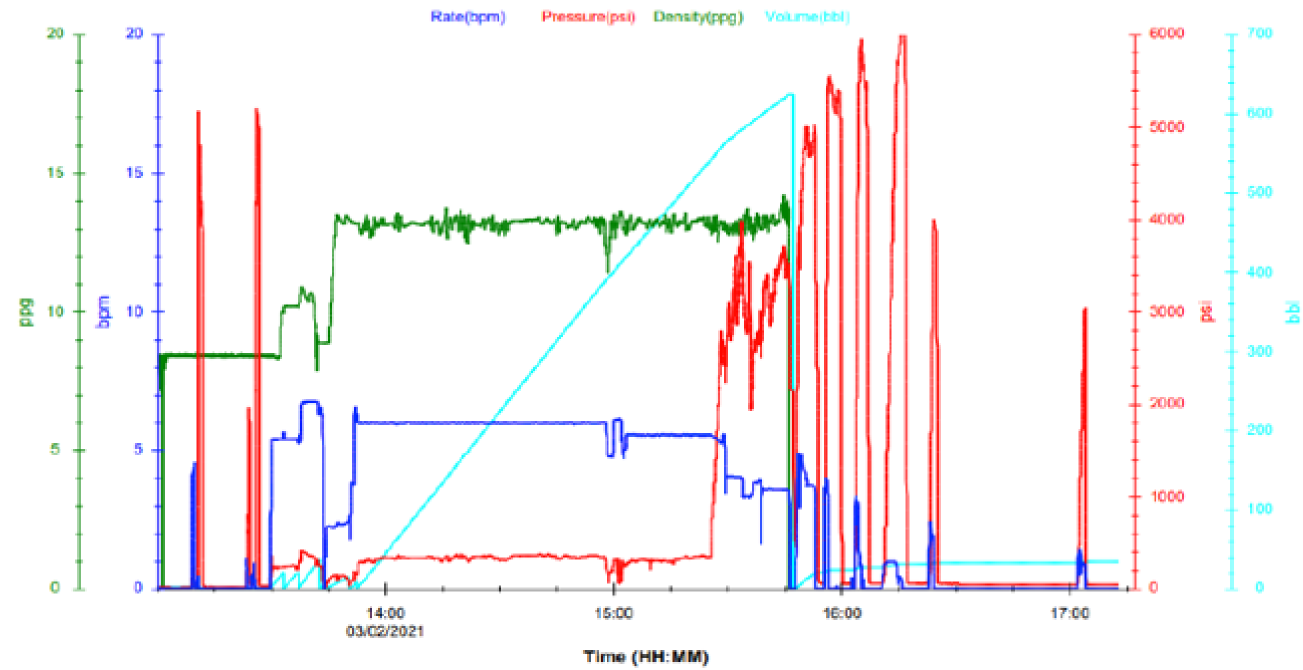


Figure 32: 5-1/2 in. Production casing cement pressure chart (primary job)

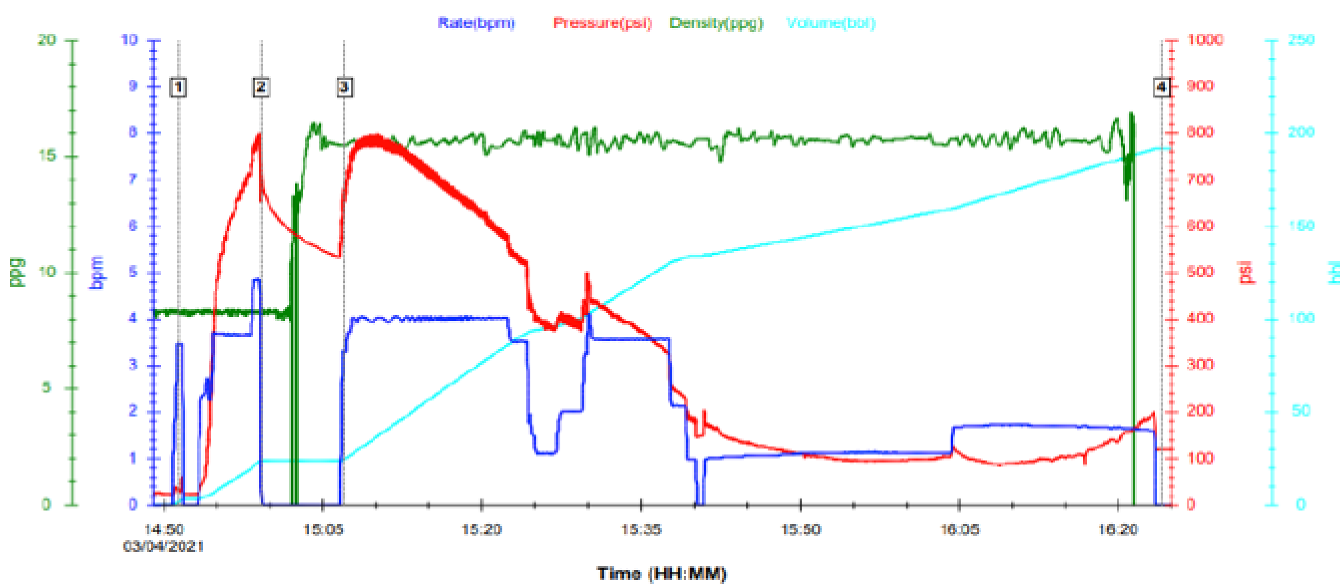


Figure 33: 5-1/2 in. Production casing cement pressure chart (secondary job)

6.4.7. Completion

The final wellhead was installed after secondary cement was set, as can be seen on Figure 34. A 4-3/4 in. bit, 4 in. PDM, cross-over and 6 joints of 4 in. drill collars (Figure 35) were used to clean out cement to

TD. Following this, another clean-out run was performed with a casing scraper added to the BHA. At 9,034 ft., mud was displaced with 266 barrels of Biocide water.

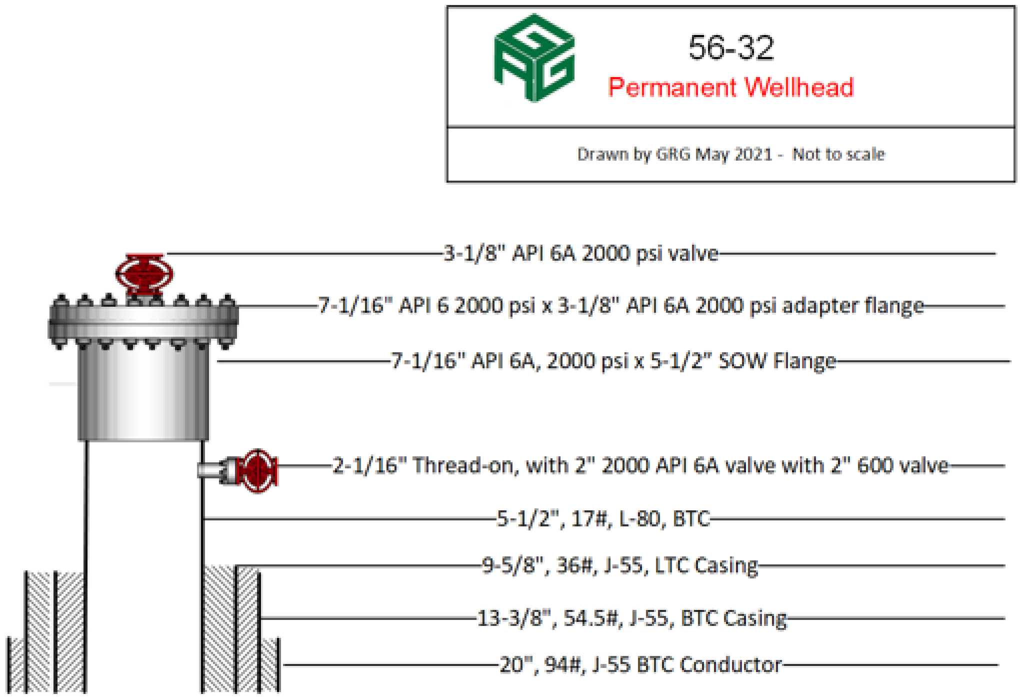


Figure 34: Permanent final wellhead

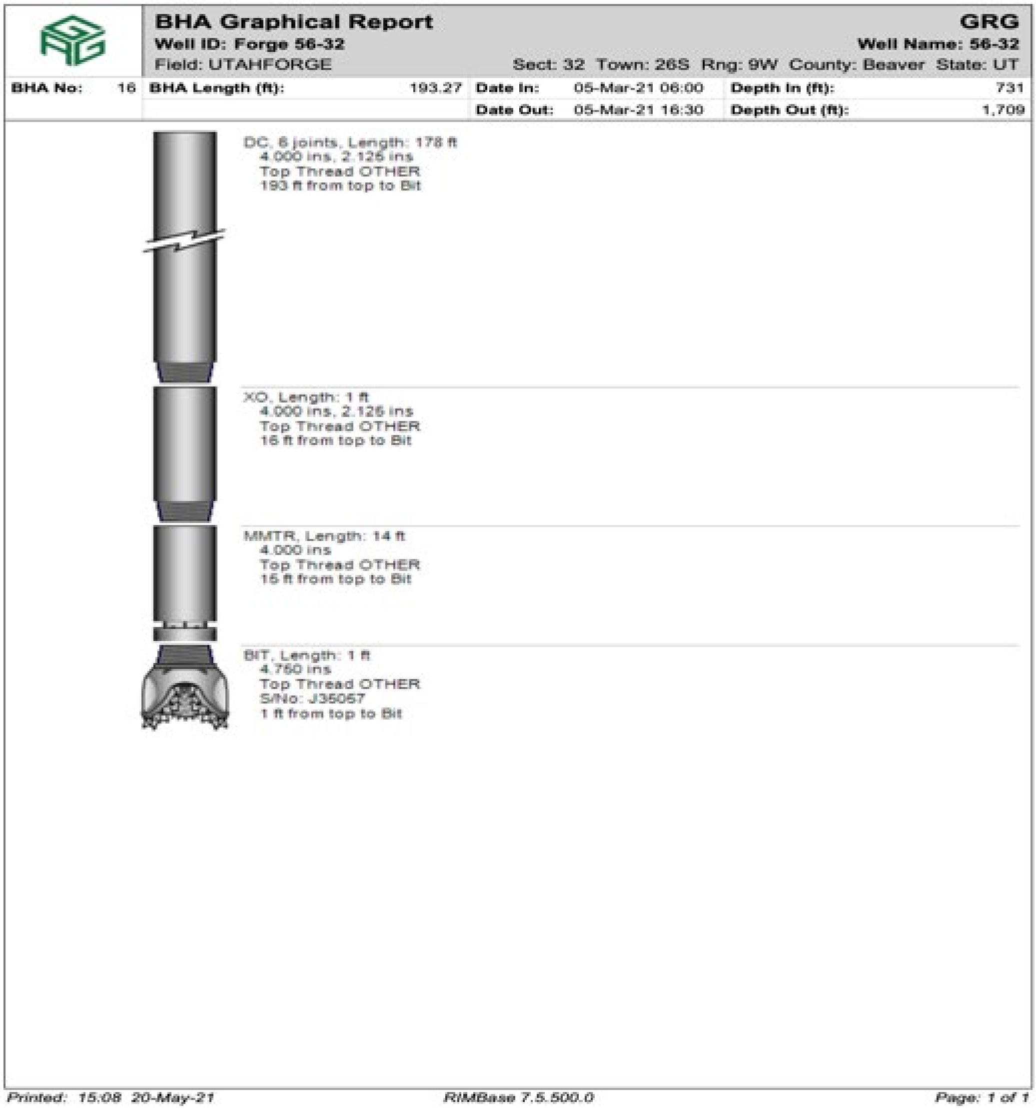


Figure 35: 4-3/4 in. BHA #16 to clean-out cement inside 5-1/2 in. casing

7. CORING

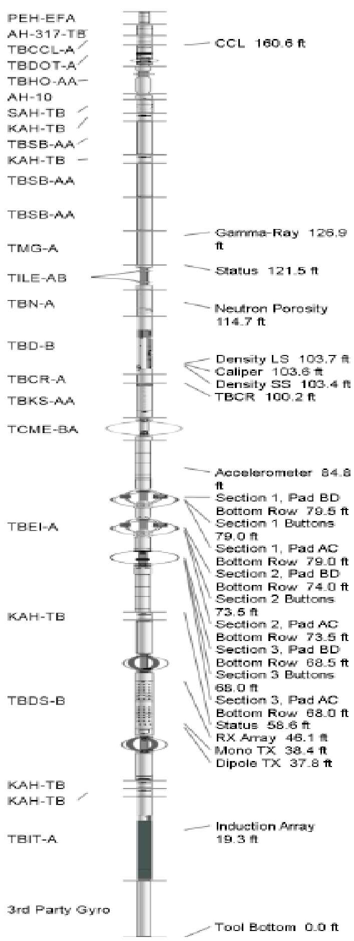
A sidewall core was attempted 6,999 ft. (after reaching was TD of 8-3/4 in. hole) using a wireline rotary system, but the core barrel failed to break the formation and recover the core, as it exceeded the tool limits, hard formation was a factor. No other coring was planned for this well.

8. DATA COLLECTION

For all section of the well cutting samples we retrieved, washed and described onsite, packaged and labeled for further analyses by the mug logging company on-site. A daily mud log and geology report was provided as well. In addition to lithology and alteration the mud log captured drilling parameters ROP, WOB, Mud temperature in and out, CO2 gas shows, and other well and drilling information. MSE was calculated within the drilling data systems and available in real time from data system. Final Mud Log is shown in Appendix 2.

Geophysical Logging

A Thru-Bit triple combo and Gyro were run on 27 February from 9,145 ft. to 3,493 ft. After reviewing the recovered the data it was noticed that there was a premature density closure. The caliper was open downhole during the system check. The caliper then closed automatically after seeing high readings from the induction resistivity tool (is designed so the caliper is made to close once the logging tool is back inside casing). So there was not full data recovery on the run.



L4- TCOM-TBEI-TBDS-Gyro

Weight in Air: 858.50 lbm, **Length**: 165.77 ft, **Volume**: 2.97 ft3, **Max OD**: 2.125 in, **Max Pressure**: 15000.00 psi, **Max Temp**: 302.00 degF

	Name	OD (in)	Rigid OD (in)	Len. (ft)	Weight (lbm)	Temp. (degF)
1	PEH-EFA	1.375	1.375	2.36	9.40	350
2	AH-317-TB	2.125	2.125	1.07	22.60	302
3	TBCCL-A	2.125	2.125	1.71	3.95	302
4	TBDOT-A	2.125	2.125	3.68	20.00	302
5	TBHO-AA	2.125	2.125	4.99	60.00	302
6	AH-10	2.125	2.125	0.75	3.95	302
7	SAH-TB	2.125	2.125	2.34	22.60	302
8	KAH-TB	2.125	2.125	1.42	15.00	302
9	TBSB-AA	2.125	2.125	6.13	5.00	302
10	KAH-TB	2.125	2.125	1.42	15.00	302
11	TBSB-AA	2.125	2.125	6.13	5.00	302
12	TBSB-AA	2.125	2.125	6.13	5.00	302
13	TMG-A	2.125	2.125	6.13	45.00	302
14	TILE-AB	2.125	2.125	4.50	70.00	302
15	TBN-A	2.125	2.125	4.77	35.00	302
16	TBD-B	2.125	2.125	10.48	91.00	302
17	TBCR-A	2.125	2.125	1.56	12.00	350
18	TBKS-AA	2.125	2.125	6.37	25.00	350
19	TCME-BA	2.125	2.125	4.08	20.00	350
20	TBEI-A	2.125	2.125	31.13	134.00	302
21	KAH-TB	2.125	2.125	1.42	15.00	302
22	TBDS-B	2.125	2.125	29.11	100.00	302
23	KAH-TB	2.125	2.125	1.42	15.00	302
24	KAH-TB	2.125	2.125	1.42	15.00	302
25	TBIT-A	2.125	2.125	15.28	94.00	302
26	3rd Party Gyro	2.000	2.000	10.00	0.00	

Figure 36: Wireline logging tool used in 56-32

9. MECHANICAL SPECIFIC ENERGY

The use of new PDC cutters and MSE allowed for an improvement in rate of penetration of more than 60% compared to well 16A-32 and 180% when compared to the first well drilled in the Utah FORGE project (58-32). The MSE formula used is described in Figure 37:

$$MSE_{Total} = \text{Axial Work} + \text{String Rotational Work} + \text{Bit Rotational Work}$$

$$MSE_{Total} = \frac{4WOB}{\pi D^2} + \frac{480\,(TOR_{Surf} - TOR_{mm})\,RPM_{Surf}}{D^2(ROP)} + \frac{480\,TOR_{mm}\,RPM_{mm}}{D^2(ROP)}$$

For motor applications this simplifies to:

$$MSE_{Total} = \frac{4WOB_{Surf}}{\pi D^2} + \frac{480\,TOR_{Surf}\,RPM_{Surf}}{D^2(ROP)} + \frac{480\,(K_t\,\Delta P)(Kn\,Q)}{D^2(ROP)}$$

For MWD applications this simplifies to:

$$MSE_{Total} = \frac{4WOB_{MWD}}{\pi D^2} + \frac{480\,TOR_{Surf}\,RPM_{Surf}}{D^2(ROP)} + \frac{480\,TOR_{MWD}\,RPM_{MWD}}{D^2(ROP)}$$

Figure 37: MSE Formulas (Harold Vance Department of Petroleum Engineering. Texas A&M University)

Drilling of the 17-1/2 in. and 12-1/4 ft. sections were very fast, and no noticeable trend was noticed on the MSE. Several drills off tests were carried out while drilling the 8-3/4 in. hole section and it was observed the limiting factor was the life of mud motors as they didn't last more than 20 to 25 hours before needing to pull out and change out motors; the bits were still in good drilling condition. After internal discussion it was decided to lay down the shock sub absorber and then it was discovered that mud motor life increased to an average of almost 50 hours per run.

Drilling continued attempting to improve ROP by keeping MSE Total was kept around 70Ksi, after performing several drill off tests.

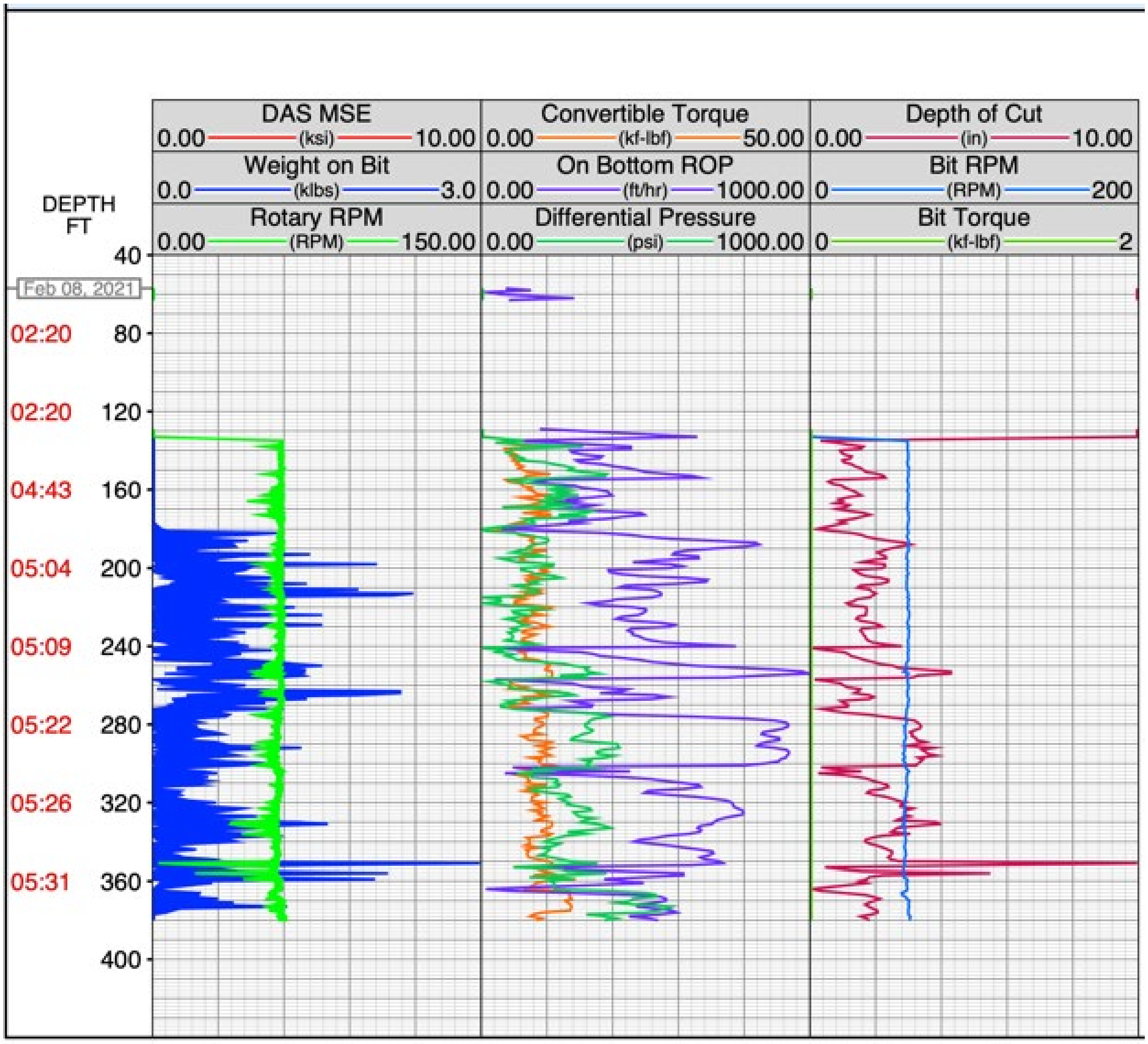


Figure 38: MSE monitored parameters while drilling the 17-1/2 in. hole section (Bit # 1)

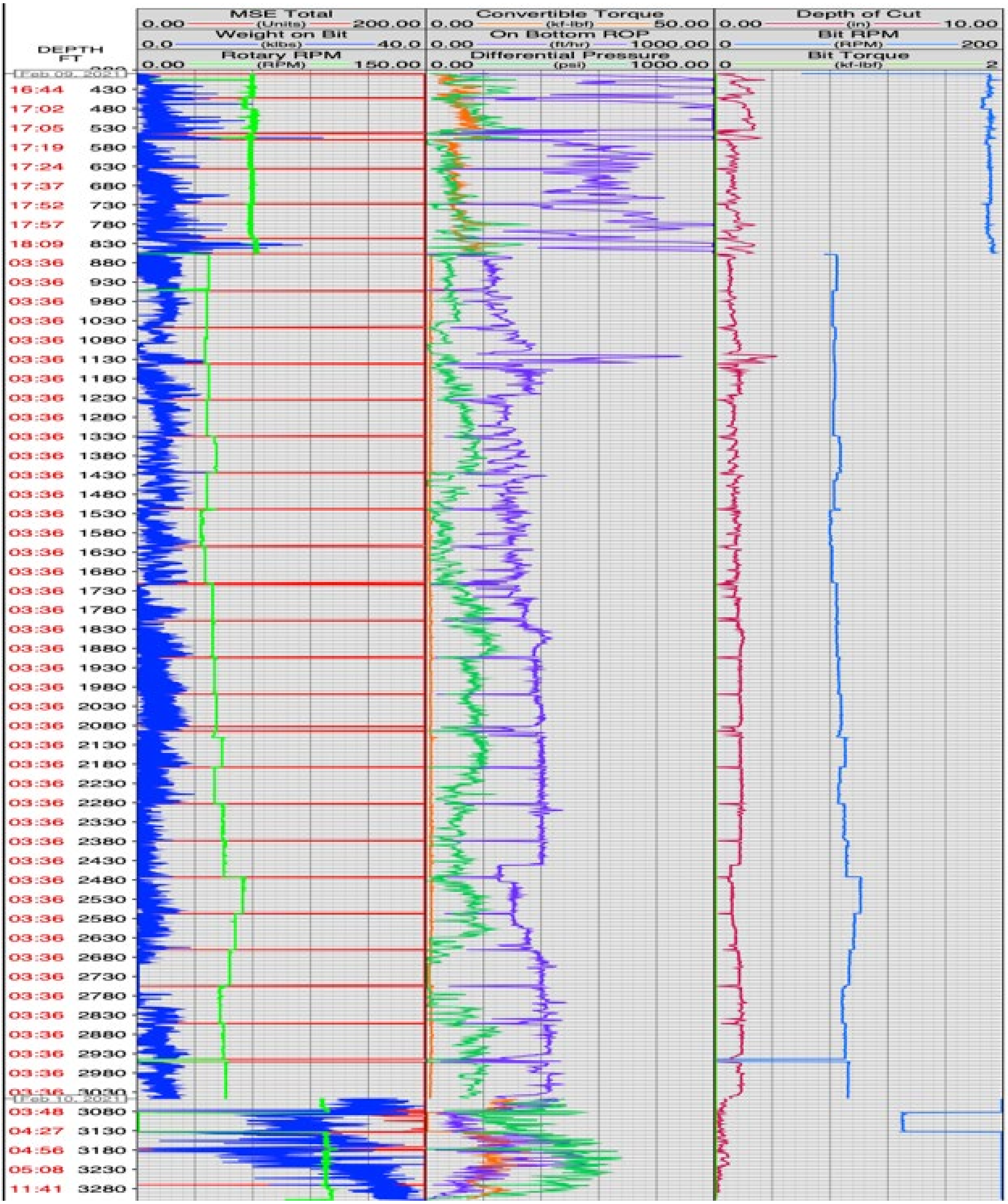


Figure 39: MSE monitored parameters while drilling the 12-1/4 in. hole section (Bit # 3)

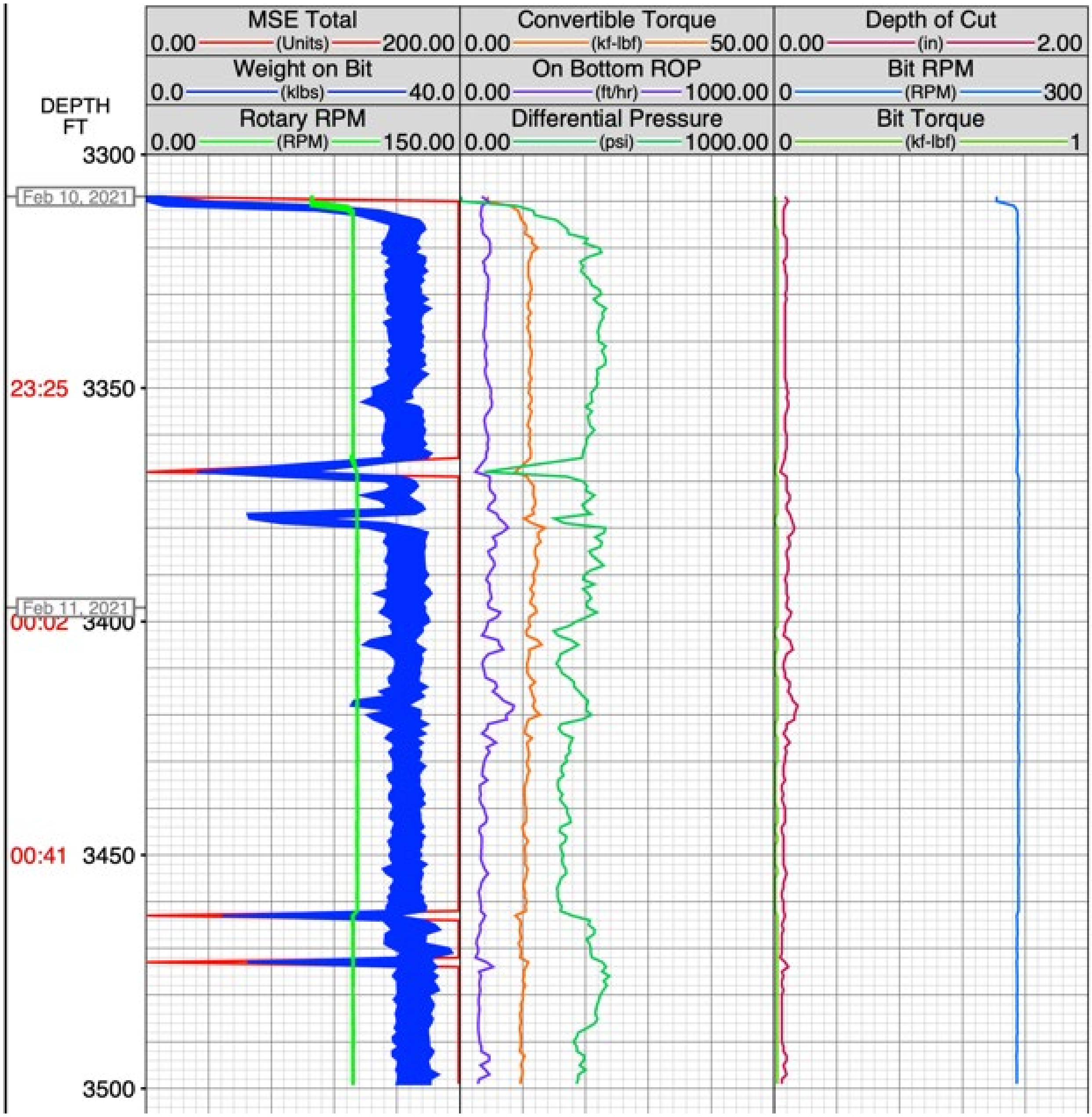


Figure 40: MSE monitored parameters while drilling the 12-1/4 in. hole section (Bit # 4)

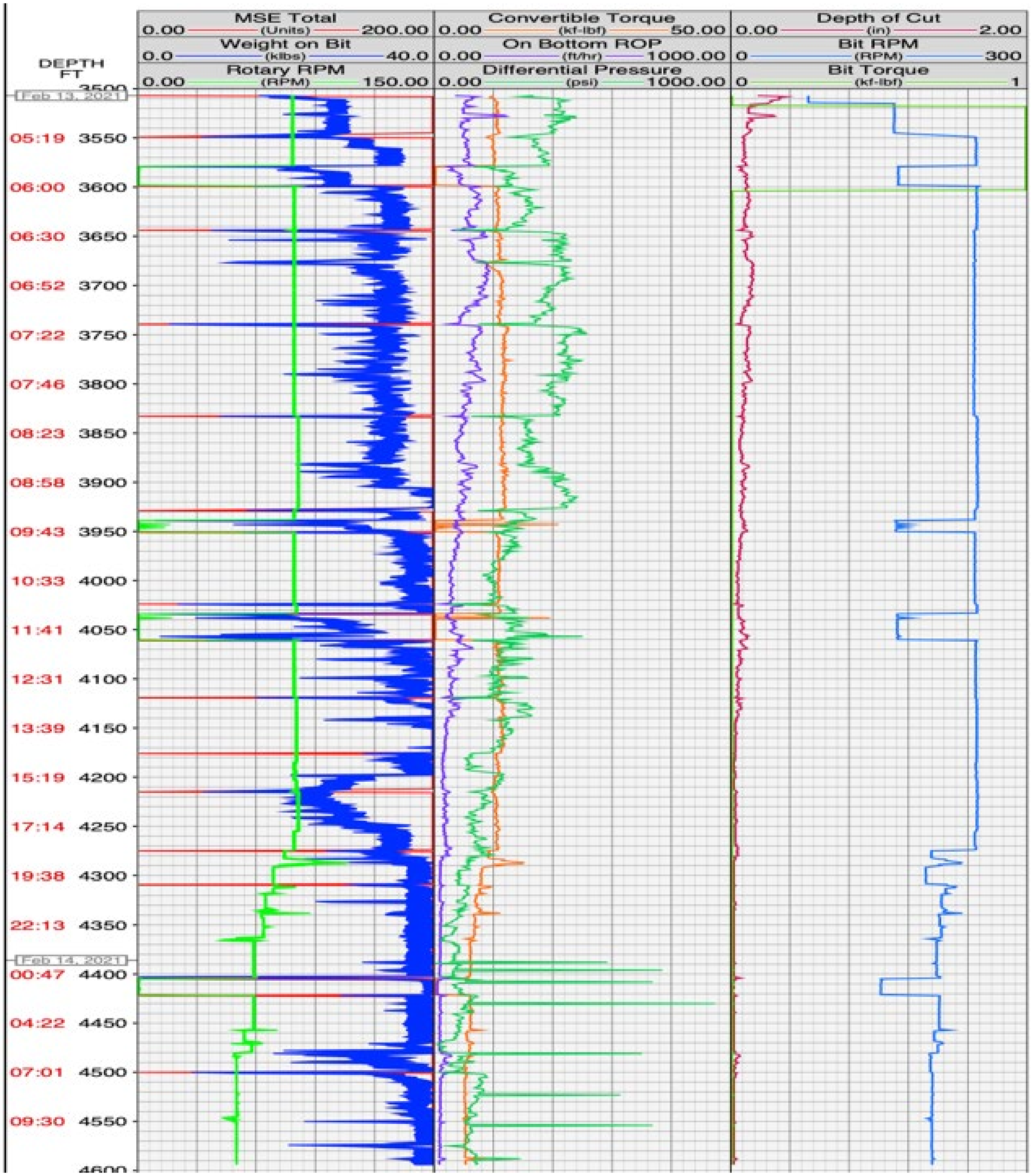


Figure 41: MSE monitored parameters while drilling the 8-3/4 in. hole section (Bit # 6)

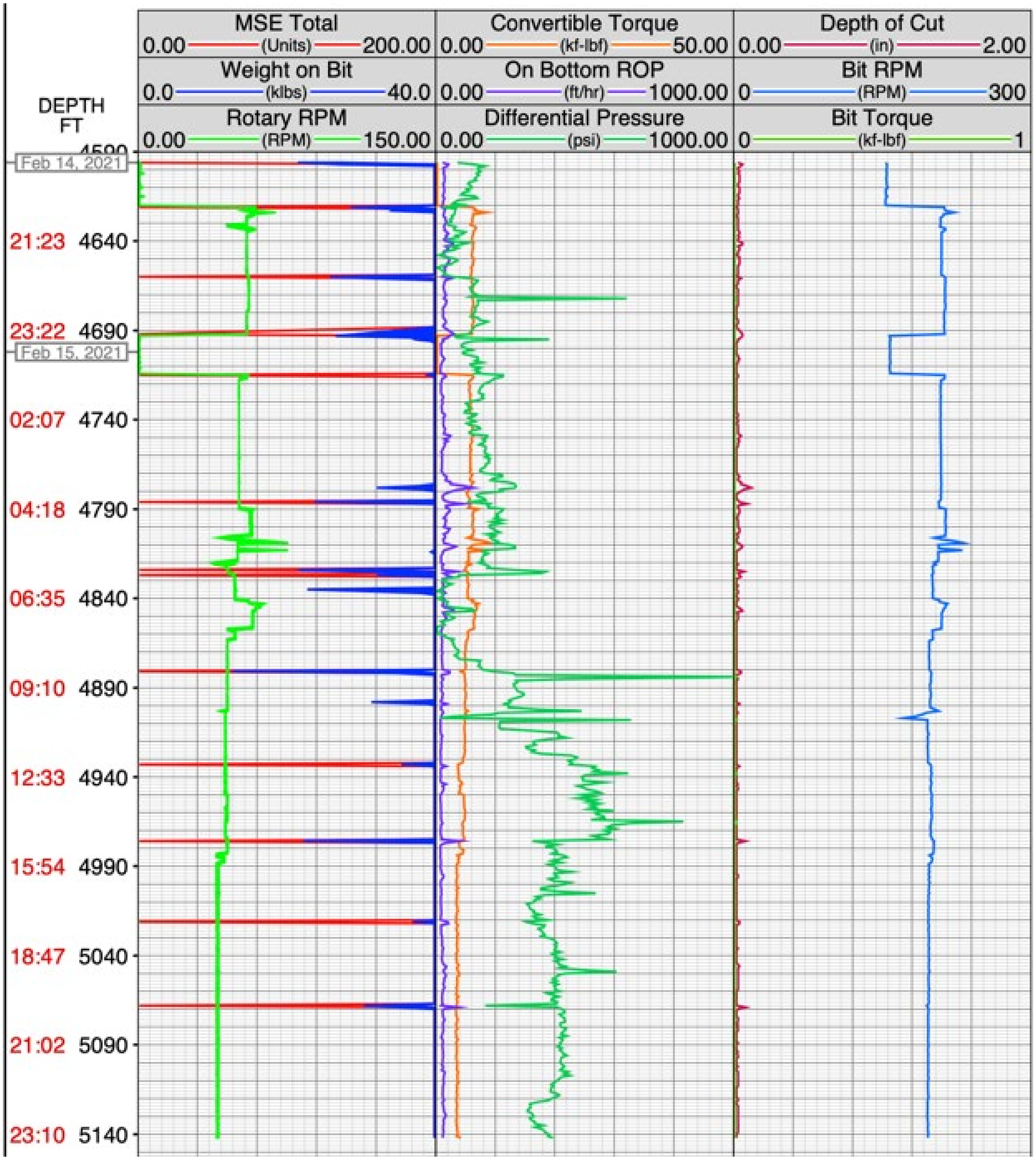


Figure 42: MSE monitored parameters while drilling the 8-3/4 in. hole section (Bit # 7)

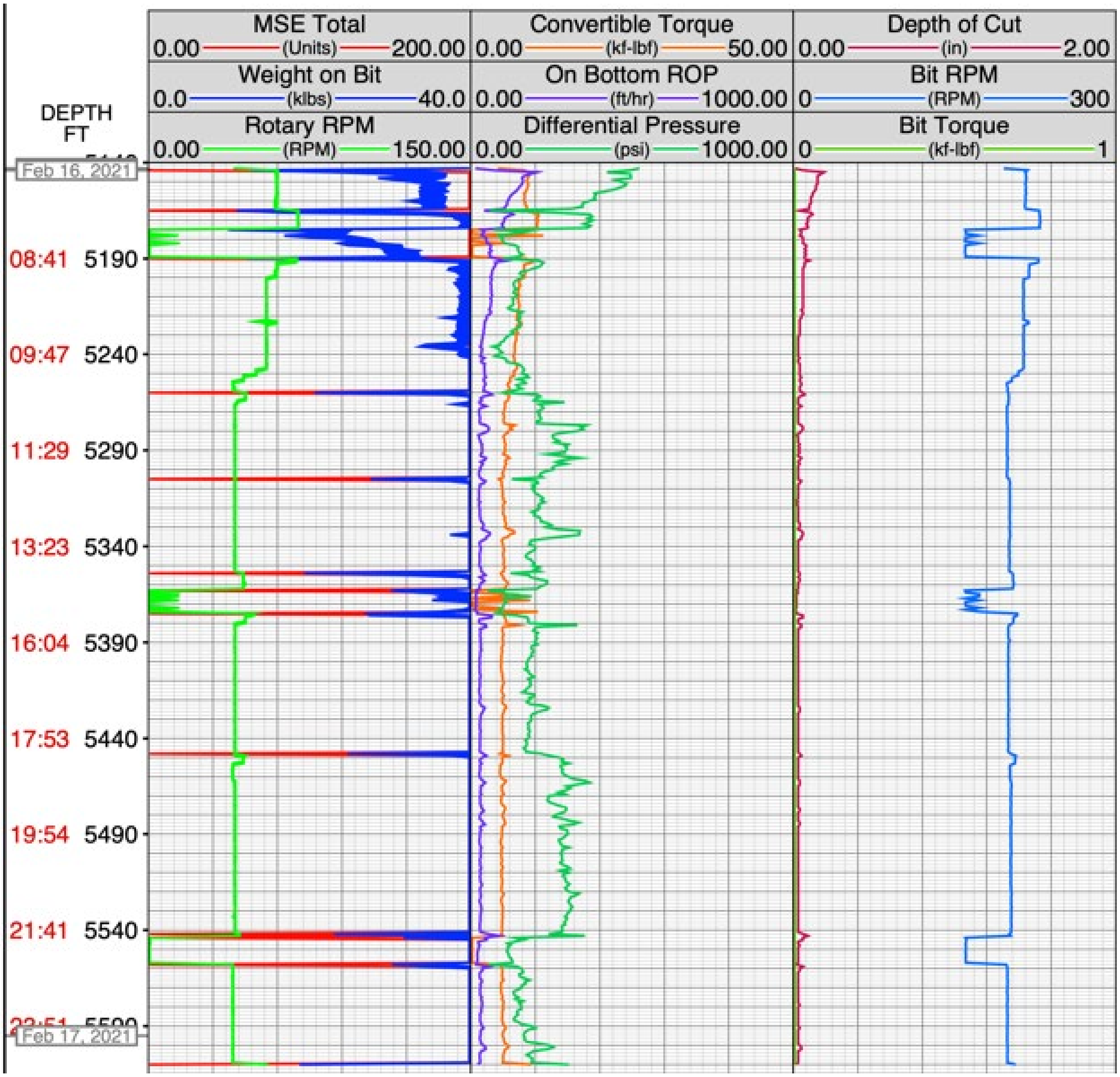


Figure 43: MSE monitored parameters while drilling the 8-3/4 in. hole section (Bit # 8)

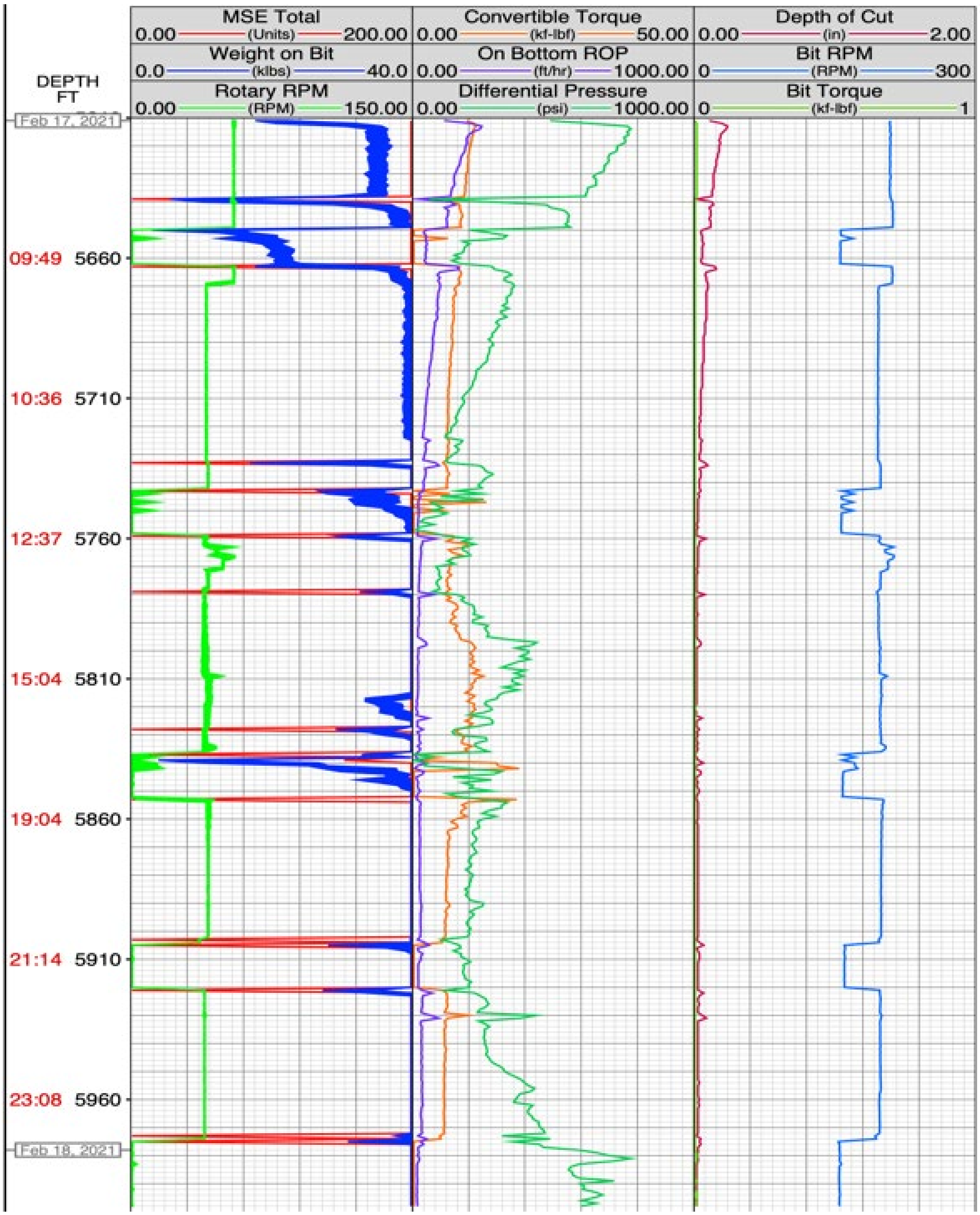


Figure 44: MSE monitored parameters while drilling the 8-3/4 in. hole section (Bit # 9)

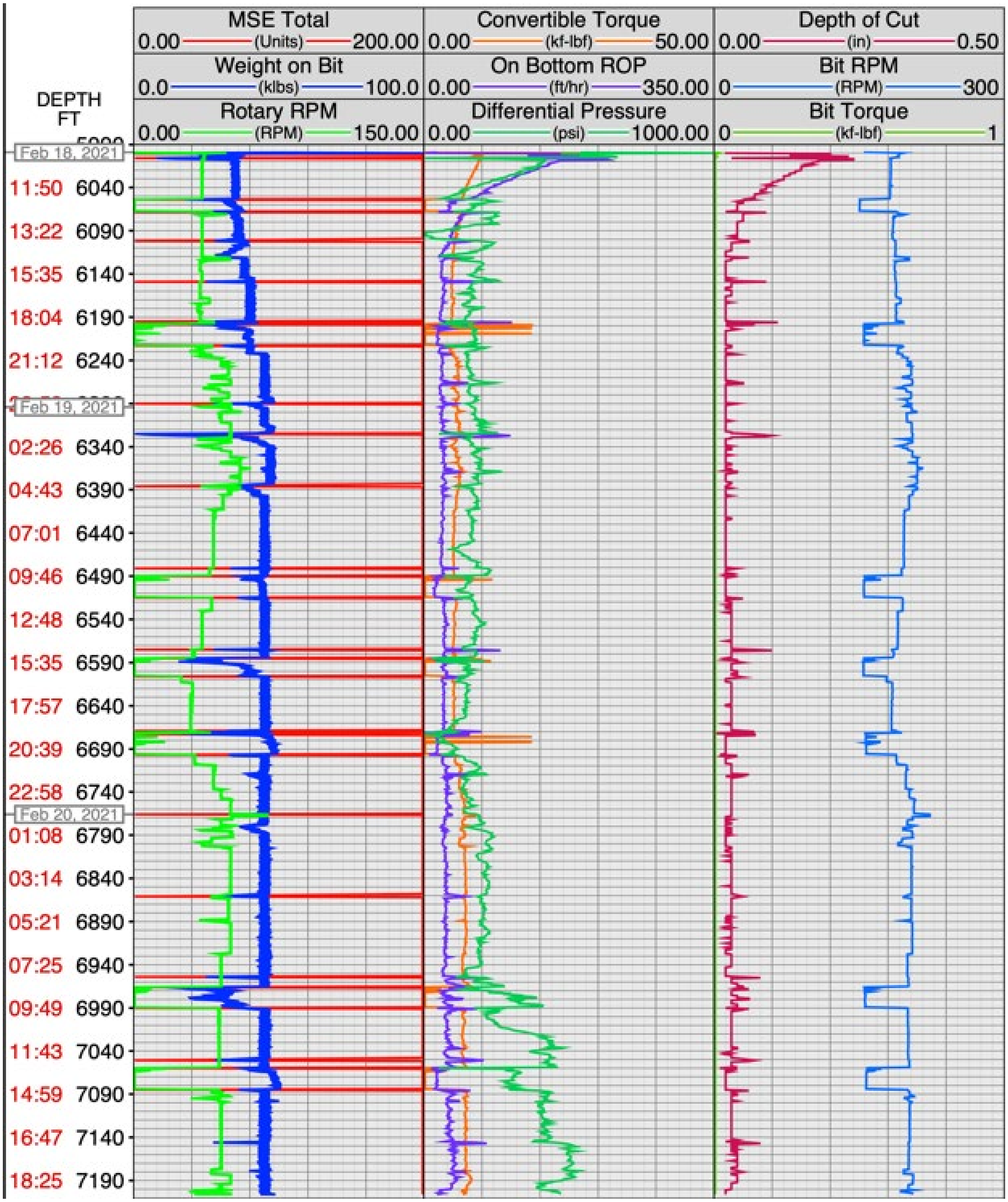


Figure 45: MSE monitored parameters while drilling the 8-3/4 in. hole section (Bit # 10)

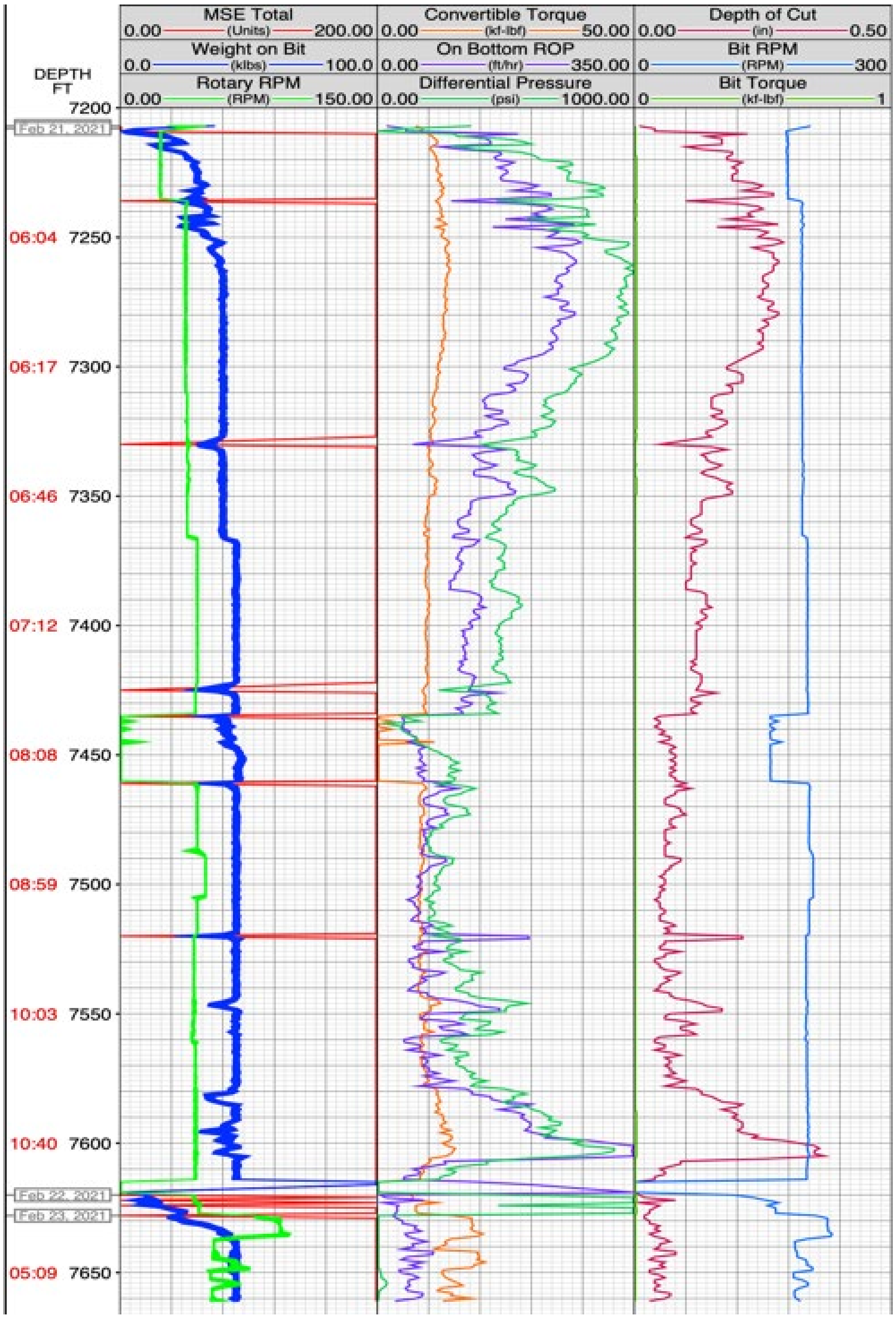


Figure 46: MSE monitored parameters while drilling the 8-3/4 in. hole section (Bit # 11)

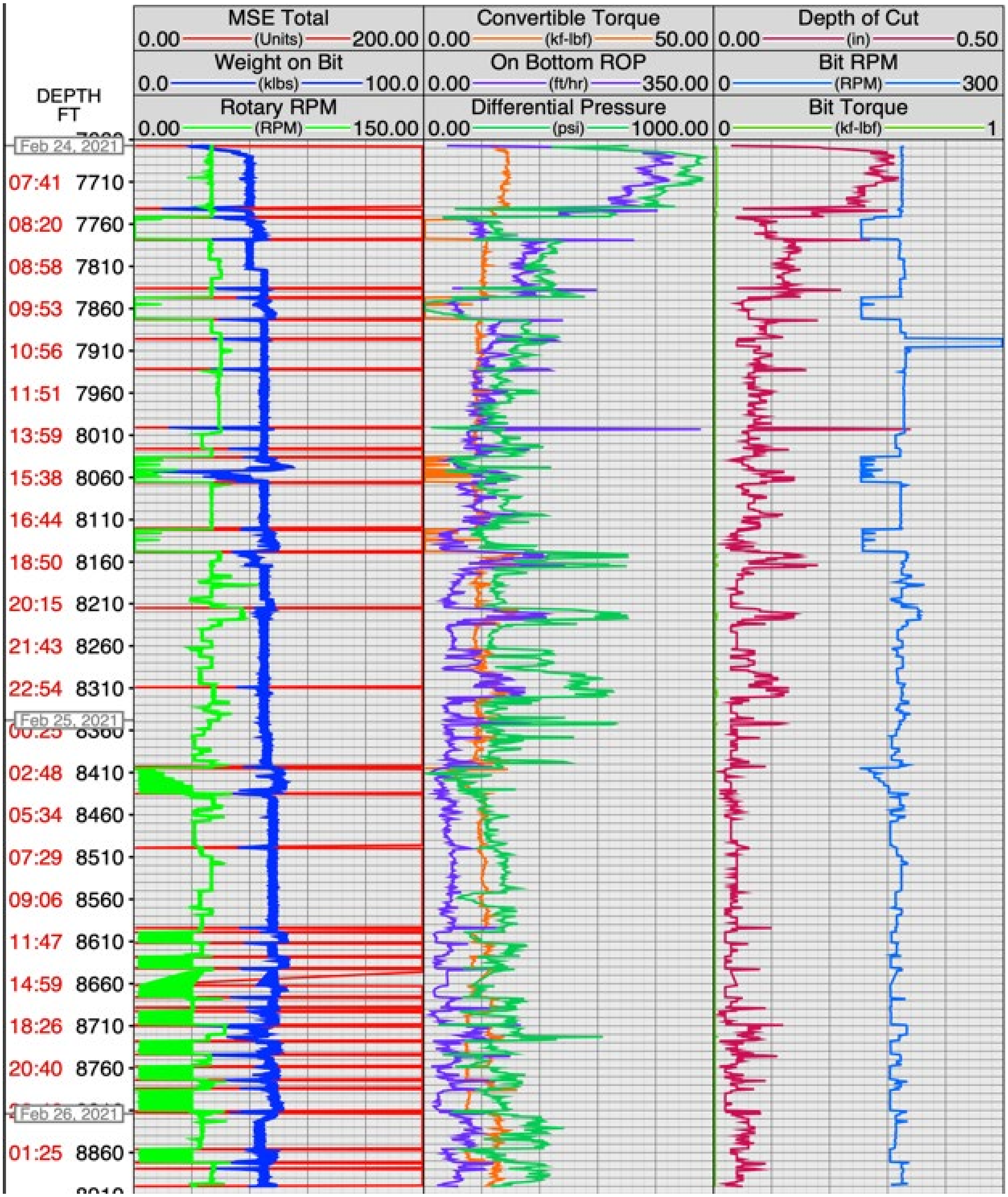


Figure 47: MSE monitored parameters while drilling the 8-3/4 in. hole section (Bit # 13)

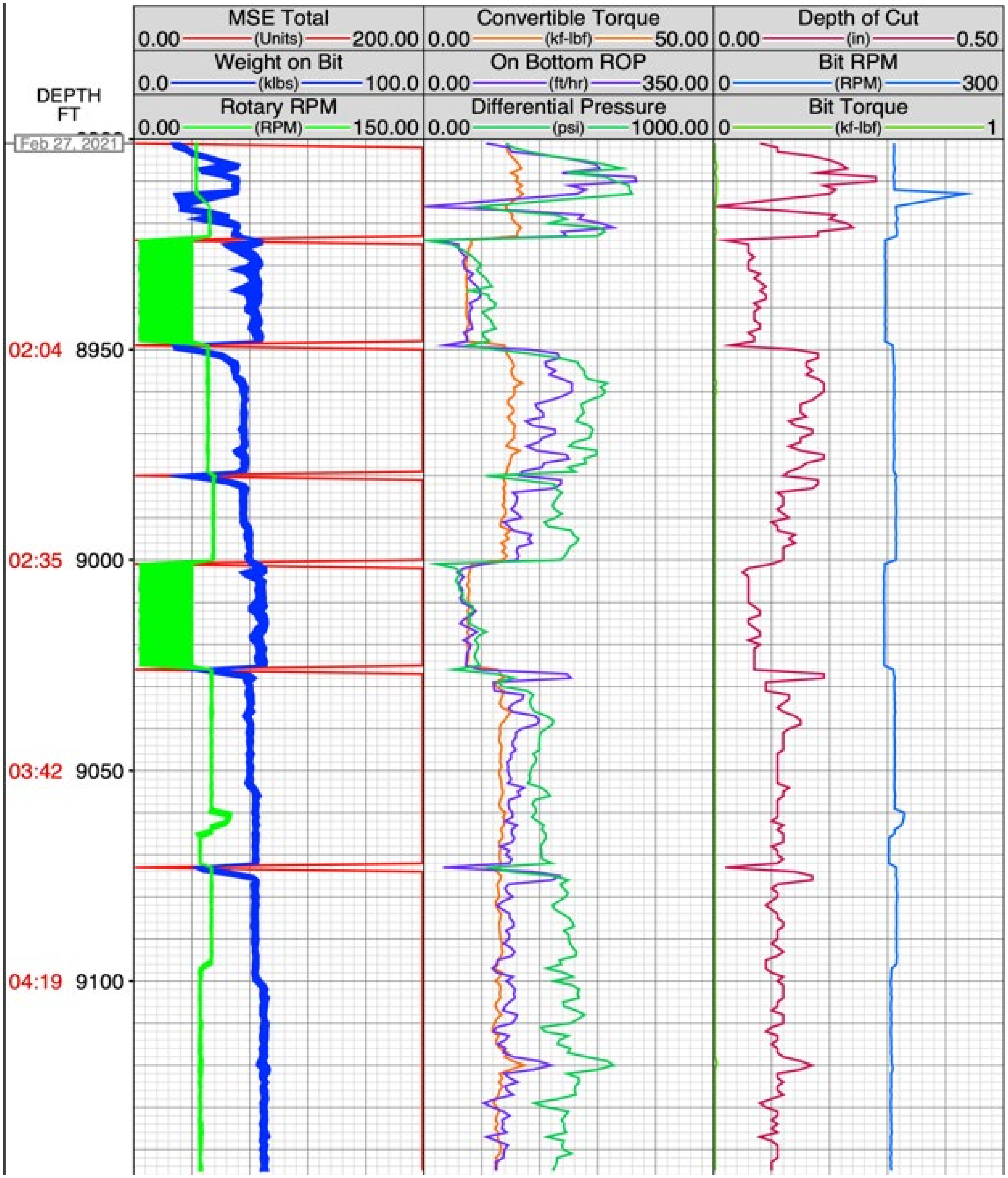


Figure 48: MSE monitored parameters while drilling the 8-3/4 in. hole section (Bit # 14)

10. LESSONS LEARNED

The following expectations, developed by the U.S. Department of Energy (Department of Energy, 1999), are intended to provide high-level guidance for developing, communicating, and using lessons learned. Due to the relatively limited size of the drilling management team, we have concentrated on a number of elements from the broader selection of DOE's lessons learned program to facilitate a meaningful lesson gathering per the size of our operation.

Program Scope

Lessons learned provide a powerful method of sharing innovative ideas for improving work processes, equipment design and operation, quality, safety, and cost effectiveness. If an organization focuses only on failures or non-compliance issues, their overall lessons learned program's effectiveness will be reduced and they will miss opportunities to improve all their processes. Lessons learned should draw on both positive experiences—innovative ideas that prevent accidents or save money, and negative experiences—lessons learned only after an undesirable outcome has already occurred. The relationships of lessons learned, and other management information sources should be clear and understood. Lessons learned should communicate only lessons and should not duplicate nor replace other management information functions like self-assessment or event investigation and corrective action systems.

Program Administration

Performance measures should focus on how well a lessons-learned program uses opportunities to develop lessons, the quality of the lessons the program creates, and how well business and operating practices integrate lessons into improvements. The lessons learned infrastructure should use existing systems where possible. Lessons learned should be part of everyone's job, but clearly defined ownership should be established for maintaining the infrastructure and support for lessons learned development, communication, and use. Lessons from any level of the organization and any location can be instructive. Local sites should evaluate outside lessons for local application and dissemination.

Information Input

The mechanisms for identifying a potential lesson learned should be simple (in terms of volume, type of information, and input mechanisms). Lessons should be context driven (information defined in terms of environment in which learned and significance). The potential types of work or subject matter should be defined (in terms of information warranting inclusion). There should be no stigma or blame assigned for individuals identifying a lesson learned.

Resources

The objective of the lessons learned programs is to provide a means of communicating experiences which can potentially reduce risk, improve efficiency, and enhance the cost effectiveness of processes and operations.

Training and Qualification

Each local organization is responsible for making personnel aware of how to access and use the local lessons learned mechanisms to identify, share and use lessons learned. Personnel such as lessons learned coordinators or subject matter experts who manage, administer, or otherwise have specific responsibilities for local lessons learned programs should possess a broad knowledge of their local organization(s), certain specialized knowledge and skills, and the ability to engage with staff to bring about the best outcomes for the program.

Examples of the broad knowledge desirable include general technical knowledge of the work performed by the organization and hazards or vulnerabilities associated with that work, the overall organizational structure and management systems, familiarity with their operator or contractor counterpart organizations, general familiarity with the regulatory environment in which the work is performed, and a general awareness of stakeholder interests. Examples of desirable prior work-related experience for lessons learned personnel include evaluation or assessment, event analysis, accident investigation, operations, team leadership or facilitation, training, change control, or similar experience that requires analysis and synthesis of information in order to determine and implement corrective or improvement actions.

Dissemination

Lessons learned should be disseminated with an assigned priority descriptor, which denotes the risk, immediacy, and urgency of the lessons learned content. Priority descriptors that define the categories of lessons learned are listed below and summarized in Table 4:

- Red >35K USD (1-day burn rate)
- Blue = 5-35K USD
- Green <5K USD
- Yellow "Good Practice"

The lessons learned priority descriptor is established by lessons learned originator. Recipients of the lesson learned may revise the priority descriptor for internal use based on the urgency and relevancy of the lesson to their organization. Red/Urgent lessons require timely dissemination, review, documentation, and tracking of actions performed. As appropriate, organizations should document and track required response actions to ensure completion and closure in accordance with the organization's corrective action and change control processes.

We have used both actual and estimated financial gains and losses, without differentiating the actual from the estimated, significantly.

(red)	>$35K	(blue)	$5K-$35K	(green)	<$5K	(yellow)	Good Practice

Development

Lessons learned documents for local use may be tailored as appropriate for local needs, but they should include enough metadata so that they can be identified and determined relevant for use within the company and within departments. Table 20 is the template for documenting lessons learned information in preparation for dissemination.

The MU-ESW1 lessons learned program was arranged by drilling project phases, from the pre-drilling and planning phase, including conductor and move in, surface, intermediate, production sections, testing, and move off phase.

Table 20: Lessons learned item presentation template

Title:	
Date:	
Identifier:	
Lesson Learned Statement:	
Discussion of Activities:	
Recommended Actions:	
Estimated Savings or Cost Avoidance:	
Priority Descriptor:	
Work / Function(s):	
Originator:	
Contact:	
Keywords:	

10.1. Lessons Learned Template Field Descriptions:

Title: Title of the lesson learned.

Date: Date the lesson learned was issued.

Identifier: Unique identification number to assist in referencing a lesson learned that includes calendar year, operations office identifier, organization or field/area office/contractor identifier, and a sequential number (e.g., 1995-CH-BNL-0019; 1995-ID-LITCO-0118).

Lessons Learned Statement: Statement that summarizes the lesson(s) that was learned from the activity.

Discussion of Activities: Brief description of the facts which resulted in the initiation of the lesson learned.

Recommended Actions: A brief description of management-approved actions which were taken, or will be taken, in association with the lesson learned.

Estimated Savings/Cost Avoidance: If the lesson learned is implemented, an estimate of the savings from the application of a good work practice or the costs avoided from the prevention of a similar event.

Priority Descriptor: A descriptive code that assigns a level of significance to the lesson.

Work/Function(s): The work or function(s) to which the lesson applies. Enter all that apply.

Originator: Name of the originating department or contractor.

Contact: Name and phone number of individual to contact for additional information.

Keywords: Word(s) used to convey related concepts or topics stated in the lesson.

10.2. Lessons Learned Items

The lessons learned registry for 56-32 is arranged by drilling phases, from the pre-drilling and planning phase, including conductor and move in, surface, intermediate and production sections, logging and move off. A color scheme is used for ranking of potential finance risk of each lesson, this is conceptual only, for the most part, as a rigorous financial analysis was not completed.

10.2.1. Pre-Drilling

Title:	Mud motor endurance
Date:	25-May-2021
Identifier:	2021-PD-GRG-EGS-0001
Lesson Learned Statement:	Mud motors should have only new components or use only new mud motors
Discussion of Activities:	Given the hard and abrasive drilling conditions, the mud motor is exposed to extremely loads. It was noticed that after taking it apart, some components needed to be replaced. When build sheets were acquire it was found that not one motor ran had been assembled with any new parts except for the lower bearings. This limited the number of hours that the mud motor can be run each time. 70% of our bit trips were due to lower bearing and housing failure which also causes uncontrollable MSE due to higher torque and less differential.
Recommended Actions:	During the bid process, ensure that each mud motor is brand new, or if rebuilt, only new components are used
Estimated Savings or Cost Avoidance:	Half a day of rig burn rate, plus mud motor repair or replacement. >$35K

Priority Descriptor:	
Work / Function(s):	Drilling, planning-bid specification
Originator:	Geothermal Resource Group, Inc.
Contact:	erivas@geothermalresourcegroup.com
Keywords:	Drilling, geothermal, planning

10.2.2. Drilling

Title:	Mud motor testing
Date:	25-May-2021
Identifier:	2021-Drilling-GRG-EGS-0001
Lesson Learned Statement:	Test mud motor without bit installed inside casing
Discussion of Activities:	All mud motors must be tested without the bit installed. Only then can the motor be lifted and bit installed. NEVER test a motor with bit inside casing. Never circulate inside casing with a PDC. This could cause damage. The cooling of the well can be done outside the casing shoe
Recommended Actions:	Test mud motor without bit installed
Estimated Savings or Cost Avoidance:	Avoid damage to the casing by testing motor with bit inside casing and ensuring that mud motor is in working conditions to avoid unnecessary trips
Priority Descriptor:	
Work / Function(s):	Drilling, planning
Originator:	Geothermal Resource Group, Inc.
Contact:	erivas@geothermalresourcegroup.com
Keywords:	Drilling, geothermal, planning

Title:	Reaming of directional drilled section
Date:	25-May-2021
Identifier:	2021-Drilling-GRG-EGS-0002

Lesson Learned Statement:	Ream drilled section or every 2,000 ft to 3,000 ft of directional work.
Discussion of Activities:	Mud Hammer was ran and 4 deg dogleg or less was recommended. Although we were fighting a severe formation dip and sliding to avoid this we ended up with 2 each 4 deg doglegs back-to-back. While running in the hole with the mud hammer and 2 roller reamers we got stuck for several hours and finally worked loose. We next ran the mud hammer with a slick assembly which resulted in a failed hammer run which was indicated for the reason for the hammer failure. We eventually had to run a conventional locked assembly and reamed out the slides. Running the hammer, the 3rd time also resulted in a failed run.
Recommended Actions:	Ream the slides twice with rotary after making them and every 2000-3000ft. of directional work that includes several slides a conventional locked assembly should be run in the hole to smooth out any directional work
Estimated Savings or Cost Avoidance:	Half a day of rig burn rate ~$20K
Priority Descriptor:	
Work / Function(s):	Drilling, planning
Originator:	Geothermal Resource Group, Inc.
Contact:	erivas@geothermalresourcegroup.com
Keywords:	Drilling, geothermal, planning

Title:	Use of Can Rig
Date:	25-May-2021
Identifier:	2021-Drilling-GRG-EGS-0003
Lesson Learned Statement:	Apply constant WOB
Discussion of Activities:	When sliding for correctional runs and to increase ROP, the CanRig system was used. This however, created discrepancies on the measurement of MSE and it seemed to interfere with directional work to keep hole vertical

Recommended Actions:	Do not use CanRig surface oscillator to improve ROP while sliding
Estimated Savings or Cost Avoidance:	Maintain hole verticality and ensure proper MSE reading
Priority Descriptor:	
Work / Function(s):	Drilling, planning
Originator:	Geothermal Resource Group, Inc.
Contact:	erivas@geothermalresourcegroup.com
Keywords:	Drilling, geothermal, planning

10.2.3. Cementing

Title:	Use of Sodium Silicate
Date:	25-May-2021
Identifier:	2021-Cementing-GRG-EGS-0001
Lesson Learned Statement:	If there are no losses detected while drilling, do not use Sodium Silicate in cement slurry as it could lead to premature set of the cement slurry
Discussion of Activities:	The role of the sodium silicate is to act as an adhesive in many applications and has been tried for wellbore strengthening. However, seems like a good idea to leave it out recognizing the apparent low fluid loss to the formation. It seems that the gelation would be accelerated by static conditions – in particular reduced convective heat transfer in the casing
Recommended Actions:	If no losses, do not use Sodium Silicate
Estimated Savings or Cost Avoidance:	>$100K. If cement set before being displaced off the casing and before filling the annulus space, it would require costly remedial cementing jobs.
Priority Descriptor:	
Work / Function(s):	Drilling, cementing operations, planning
Originator:	Geothermal Resource Group, Inc.
Contact:	erivas@geothermalresourcegroup.com
Keywords:	Drilling, geothermal, planning

Title:	Use of Silixa cable to determine bottom hole temperature
Date:	25-May-2021
Identifier:	2021-Cementing-GRG-EGS-0002
Lesson Learned Statement:	Obtain proper bottom hole temperature prior to cement casing
Discussion of Activities:	After pumping 537 bbls of cement, pressure start increasing rapidly from 500 psi to 1,800 psi. Continue to pump cement and shut down at a total volume of 620 bbl. of cement then shutdown, pump 2 bbls of water

	then drop top plug, to displace with displacement fluid while the casing was reciprocated. Only 27 bbls of displacement fluid were able to be pumped and displacement was shut down due to high pressure ~ 6,200 psi that were at the limit of the casing Capacity. When a Silixa cable is installed, and you have continuity on bottom Silixa has the ability to stay on site and monitor the temperatures in the entire wellbore during circulating and cementing procedures
Recommended Actions:	After setting casing, circulate bottoms up until no drop in return temperature is noticed, or if Silixa cable is available, request to have an updated temperature profile. Adjust cement slurry accordingly
Estimated Savings or Cost Avoidance:	>$100K
Priority Descriptor:	
Work / Function(s):	Drilling, planning, Cementing Operations
Originator:	Geothermal Resource Group, Inc.
Contact:	erivas@geothermalresourcegroup.com
Keywords:	Drilling, geothermal, planning

Title:	Reciprocation of casing
Date:	25-May-2021
Identifier:	2021-Cementing-GRG-EGS-0003
Lesson Learned Statement:	If optic cable is installed, do not reciprocate casing
Discussion of Activities:	Cementing of the 5-1/2 in. casing started on 2 March 2021 without cement returns back to surface, it was suspected at the time that there was a bridge in the hole-casing annulus and the 5-1/2 in. was reciprocated to regain circulation (this action caused the Silixa to part in tension, as it was later discovered).
Recommended Actions:	Never reciprocate casing if fiber cable is installed on the OD of the casing
Estimated Savings or Cost Avoidance:	>$100K

Priority Descriptor:	
Work / Function(s):	Cementing operations
Originator:	Geothermal Resource Group, Inc.
Contact:	erivas@geothermalresourcegroup.com
Keywords:	Drilling, geothermal, planning

APPENDICES LIST

1) Daily Drilling Reports
2) Final Mud Log
3) Casing Run Reports
4) Bit Performance Reports
5) BHA Reports
6) Caliper Log
7) 5-1/2 in. casing-cement incident analysis report