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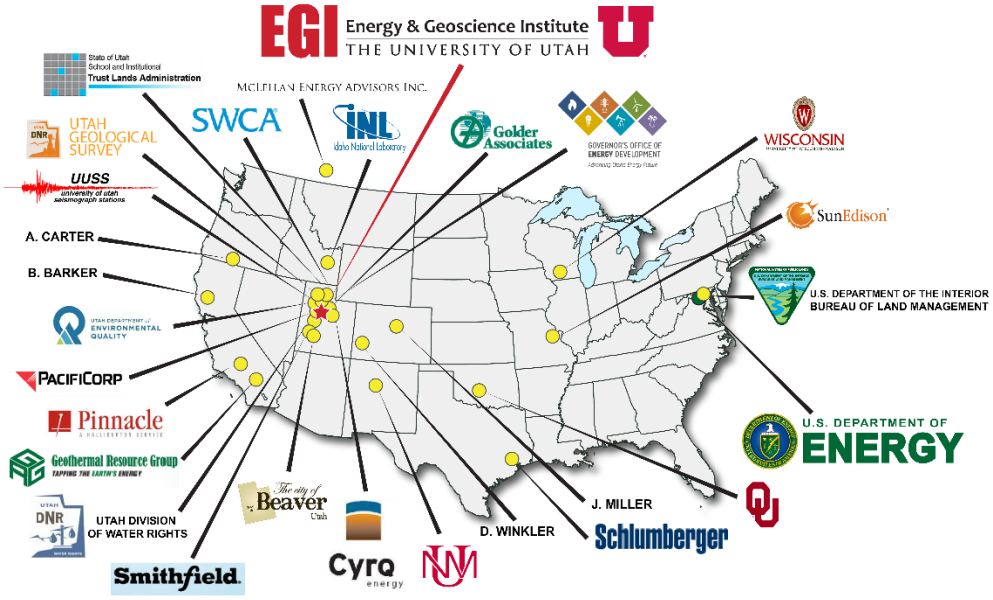
END OF WELL REPORT
for Well 58-32



CLASSIFICATION:
MID-SIZE / VERTICAL / EGS EXPLORATION WELL

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for

UniversityofUtah(U of U)

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1. Summary

Department of Energy FORGE initiative Phase 2B Well 58-32 was drilled to a depth of 7,536 ft (2,297 m) to obtain direct measurements on rock type, temperature, permeability and stress within the Utah FORGE reservoir. Well 58-32 encountered the top of the granite at about 3200 ft. (975 m) and the top of the FORGE reservoir at 6500 ft. (1980 m) based on expected formation temperature. Drilling tool selection kept the rate of penetration reasonable through the hard rock formation. The well was cased with 7-inch casing to a depth of 7,374 ft. (2,247 m). Core samples were collected near the top of the expected reservoir and at total depth, prior to running the casing in the hole. Injection testing and fall-off pressures provide data on the permeability of the crystalline rock. Additional data were obtained, including a suite of geophysical logs, pressure and temperature surveys, and microresistivity image logs. An injection test was conducted in the open hole section of the well. The temperature surveys indicate over 350°F (175°C) at the reservoir depth, as required for the FORGE initiative enhanced geothermal systems laboratory. The drilling and testing of 58-32 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 21.5 ft. above ground level, unless stated otherwise.

Table 1: Table abbreviations and acronyms.

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

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
KPI	key performance indicators
LCM	lost circulation material
LGS	low gravity solids
LOT	leak off test
LSR	Life-saving rules
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
N/D	nipple down
NMDC	non-magnetic drill collar
NPT	national pipe thread
OD	outer diameter
P/U	pick up
PDC	polycrystalline diamond compact

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
PVT	pit volume totalizer
RD/MO	rig down and move off
RMG	rig manager
ROP	Rate of Penetration, given in feet per hour
sFIT	step-rate formation integrity test
U of U	University of Utah
xLOT	extended leak off test

Table 2: Table of units and their symbols used during drilling of 58-32.

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)	°/100
FlowRate-1	Moderate flow rate – pump flow	gpm
FlowRate-2	Large flow rates – gas flow rate	scfm
FlowRate-3	Large flow rate - cement, mud/water loss	bpm
Fluid Density	Fluid density – mud weight/density	ppg
Gas	Gas concentrations – trip and connection	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	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 58-32, drilled vertically to a depth of 7,536 ft., is the first well of an exploration program in the Milford area Frontier Observatory for Research in Geothermal Energy (FORGE) UTAH Enhanced Geothermal System (EGS) prospect area (FORGE Deep Well Site). The project is administered by the U.S. Department of Energy and managed by the University of Utah (U of U).

The Opal Mound Fault separates the Roosevelt Hot Springs hydrothermal system to the east from the conductive thermal regime surrounding the FORGE site to the west. The target rock formation for 58-32 was granite and gneiss below the alluvium. The target represents a region of hot crystalline rock suitable for EGS development. The intent of the drilling was to determine the characteristics of the rock within in the target formation and at the depth and temperatures of interest.

Specific objectives of 58-32 were to:

- Investigate temperature, permeability, stress directions, stress magnitudes, and rock type to determine if reservoir conditions suitable for EGS development exist
- Gather geological and reservoir data to improve future well targeting and aid in resource modeling and assessment
- Conduct a minifrac test to determine the conditions needed to create new fractures or open existing fractures
- Drill the wells to the proposed TD within the estimated time and budget

These well objectives were achieved through geological and reservoir data that was collected as per plan and will be fundamental in the resource modeling and assessment. The drilling and testing phases confirmed that the site meets the temperature, rock type and permeability requirements established by the DOE for an EGS site. The well was also drilled under budget, in a shorter time than planned (58 days verses 73 days planned), and 536 ft. deeper than planned.

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 objective was to comply with the safety and environmental standards of the U of U and to achieve 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:

- 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

As a result of this, no LTIs were reported during operations, no environmental hazards or any environmental impact were observed and there were no major or catastrophic service quality incidents.

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 is included as appendices to this report.

4. **Well Information**

4.1. Well Location

The 58-32 well site is located within the 1.9 mi2 (4.9 km2) FORGE deep drilling site west of the Mineral Mountains, it is 217 mi (350 km) south of Salt Lake City and 10 mi (16 km) north-northeast of the town of Milford (Figure 1). The site is located in the Milford Energy Corridor in eastern Beaver County, Utah. The project area is rural and covers approximately 15.5 mi2 (25 km2). Table 3 contains the basic well information for well 58-32.

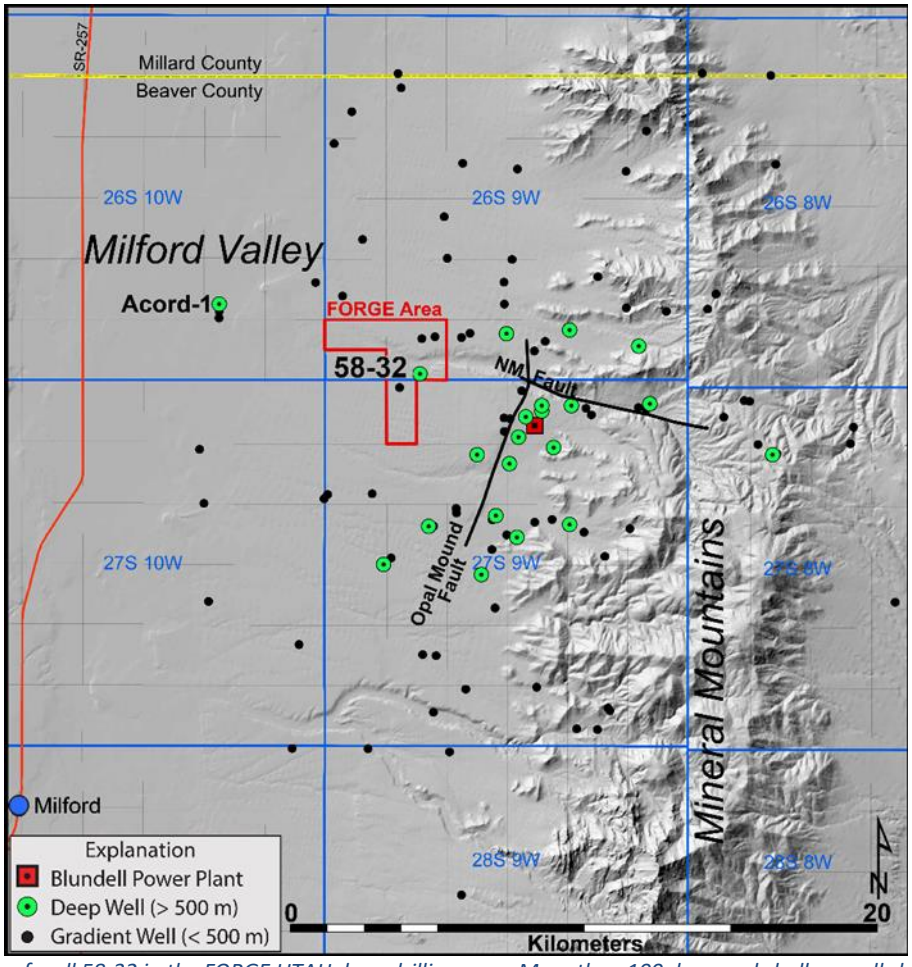


Figure 1: Location of well 58-32 in the FORGE UTAH deep drilling area. More than 100 deep and shallow wells have been drilled since the 1970s.

Table 3: Basic well information for well 58-32.

Country/Area:	USA / Milford, UT
Field:	FORGE UTAH
Operator:	University of Utah (U of U)
Drilling Project Manager	Geothermal Resource Group (GRG)
Drilling Contractor (PM):	Kenai
Drilling Rig:	Rig-10
Well Name:	58-32
Well Type:	Mid-size, vertical, exploration well
Well Location:	FORGE UTAH, A-2 Pad Northing: 4263043 m Easting: 335450 m Elevation: 5,536 ft (1,687 m)
Coordinate Reference System:	NAD83, Zone 12 UTM m
Rotary Table Height (KB):	21.5 ft from ground level
Ground Level (GL):	5,536 ft ASL
Rotary Table (KB) Elevation:	5,557.5 ft ASL
Planned Depth:	7,060 ±450 ft (within 5° inclination from vertical at TD)
Actual Depth:	7,536 ft (2.30° inclination at TD)

4.2. Planned wellbore construction and well plan

Well 53-32 (originally named MU-ESW1) was planned as a mid-size, vertical, EGS exploration well to a total depth of 7,060’, with two cored intervals within the formation of interest (Figure 2). A 20” conductor casing was to be set at 40’, a 17-1/2” surface hole with cemented 13-3/8” casing was planned to 300’, the intermediate 12-1/4” hole with cemented 9-5/8” casing was planned to 2,100’, below this an 8-3/4” hole to 7,060’, with cemented 7” casing to 6,900’, with open hole to total depth.

The geologic prognosis for the well was based on the lithologic logs from Acord-1, 9-1, and OH-4 wells along with some gravity modeling data. Thicknesses of units were only moderately constrained by the surrounding well data. Alluvium and some rhyolitic tuff mixed in with tuffaceous valley fill and lacustrine sediment were expected to about 2,100’. Below this the formation was expected to be interfingered zones of Precambrian biotite-quartz-feldspar gneiss and Tertiary granitic intrusive of varying composition. The formations were primarily known from the surrounding ranges.

MU-ESW1 was expected to intersect the target temperature in the formation of interest at 6,500 ft. The primary target for Diagnostic Fracture Injection Test (DFIT#1) was between 6,900 and 7,060 ft. The secondary target (DFIT #2) was between 6,800 and 6,830 ft., and was to be accessed through perforation of the 7” casing at that depth. Core collection was planned for 6,800 to 6,830 ft. and 6,970 to 7,000 ft.

Time to drill was estimated based on expected well construction as well as using the expected rate of penetration for experience drilling in hard granitic formation. The estimated time was 64

days for drilling and testing, the anticipated was 73 days, and the budget estimate was 85 days. Actual drilling and testing was completed in 63 days from commencement of drilling and to a deeper TD of 7,536 ft.

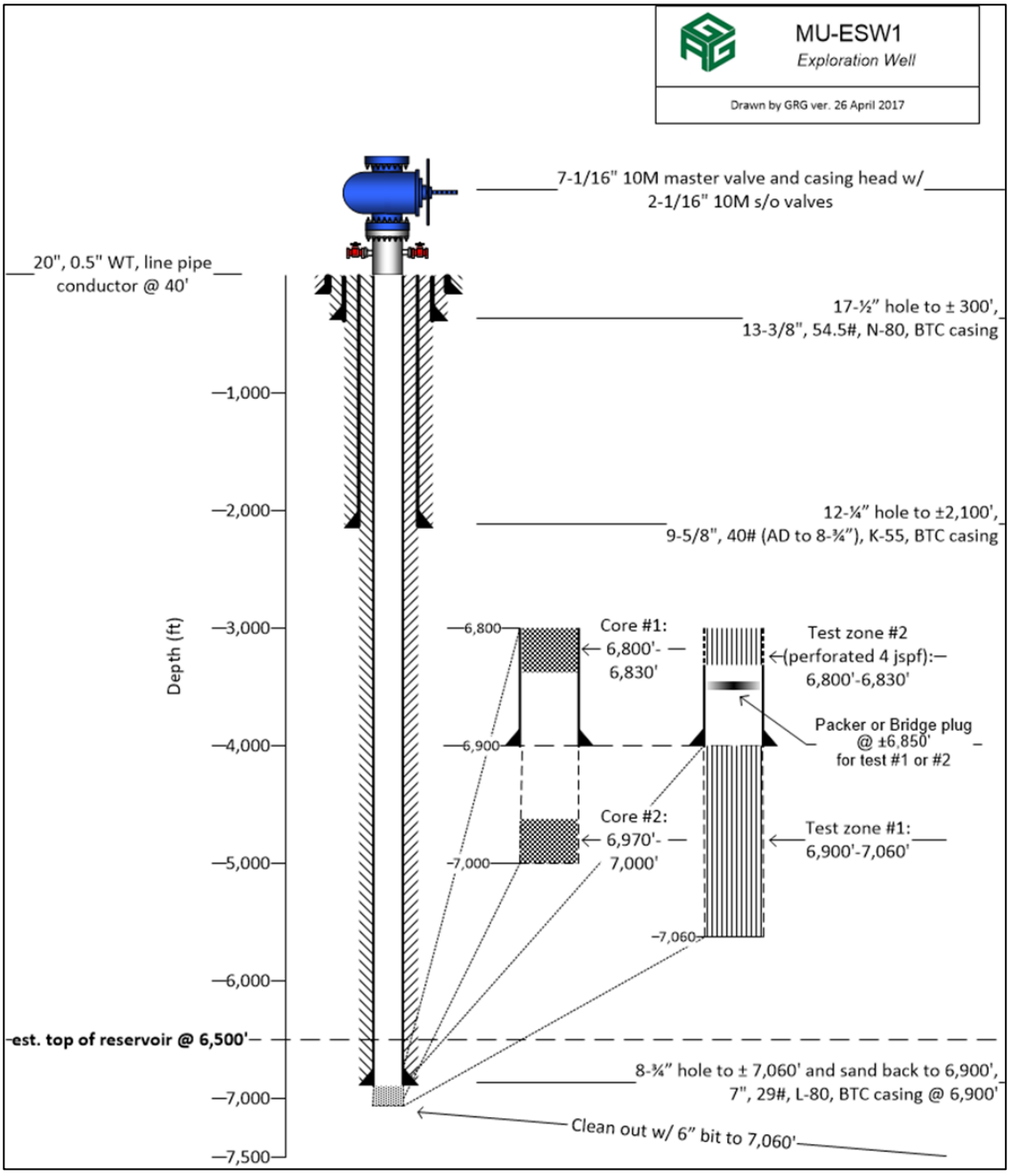


Figure 2: Planned well construction for MU-ESW1 (now 58-32).

4.3. 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" conductor pipe was cemented with the casing

shoe at 83.5 ft. on 10 July 2017. The Kenai Rig completed mobilization and rig up on 30 July 2017, and drilling commenced on 31 July 2017. The 17-1/2" hole was drilled to 342 ft. and 13-3/8" casing was cemented to 338 ft. on 2 August. Drilling of the 12-1/4" hole commenced on 3 August, tagging cement at 290', and continued to 6 August, when the casing point of 2180' was reached. The 9-5/8" casing was set and cemented at 2,172' measured depth on 7 August. The drilling of the 8-3/4" hole commenced on 8 August, and total depth of 7,536 ft. was reached on 14 September. Two cores for a total of 35 ft. from two locations, one at 6,800 ft. and the second at 7,440 ft., were collected as part of the drilling program. A full suite of geophysical open hole logs were run in the 8-3/4" section. Pressure and temperature surveys were performed at 6800'. Additionally, an acoustic image log was performed in the 8-3/4" hole from the bottom of the 9-5/8" casing to TD. After the drilling was completed, 7" blank casing was cemented to 7,375'. The bottom 161' of the hole was cleaned and left open to be tested. For the testing, a packer was run in on drill pipe and set at the bottom of the 7" casing, fluid was injected into the open hole section at various pressures to determine injectivity and to determine rock properties. After the injection test, a second acoustic image log was run in the open hole section. The rig was released on 24 September. A final warm-up survey was performed on 2 November 2017.

4.4. Wellbore as constructed

Table 4 shows the casing specifications and depths for actual construction of the 58-32 wellbore.

Table 4: 58-32 hole sections, as constructed.

Section	Hole Size (")	Casing Size (")	Specifications	Nominal ID / Drift ID/ Coupling OD (")	Actual Depth (ft)	Remarks
Conductor	n/a	20	A53B, 0.25" WT, Welded	17.5/17.5/ n/a	83.5	Preset
Surface	17-1/2	13-3/8	54.5 ppf, N-80, BTC (non-API)	12.615 / 12.459 / 14.375	337.5	Cemented well control string. Set in 100% alluvium
Intermediate	12-1/4	9-5/8	40 ppf, L-80, BTC	8.835 / 8.750 (AD) / 10.625	2,172	Cemented intermediate string. Set in 100% alluvium
Injection	8-3/4	7	29 ppf, L-80, BTC	6.276 / 6.151 / 7.656	7,374	Set in 100% granite

Figure 3 shows the planned and actual construction of well 58-32.

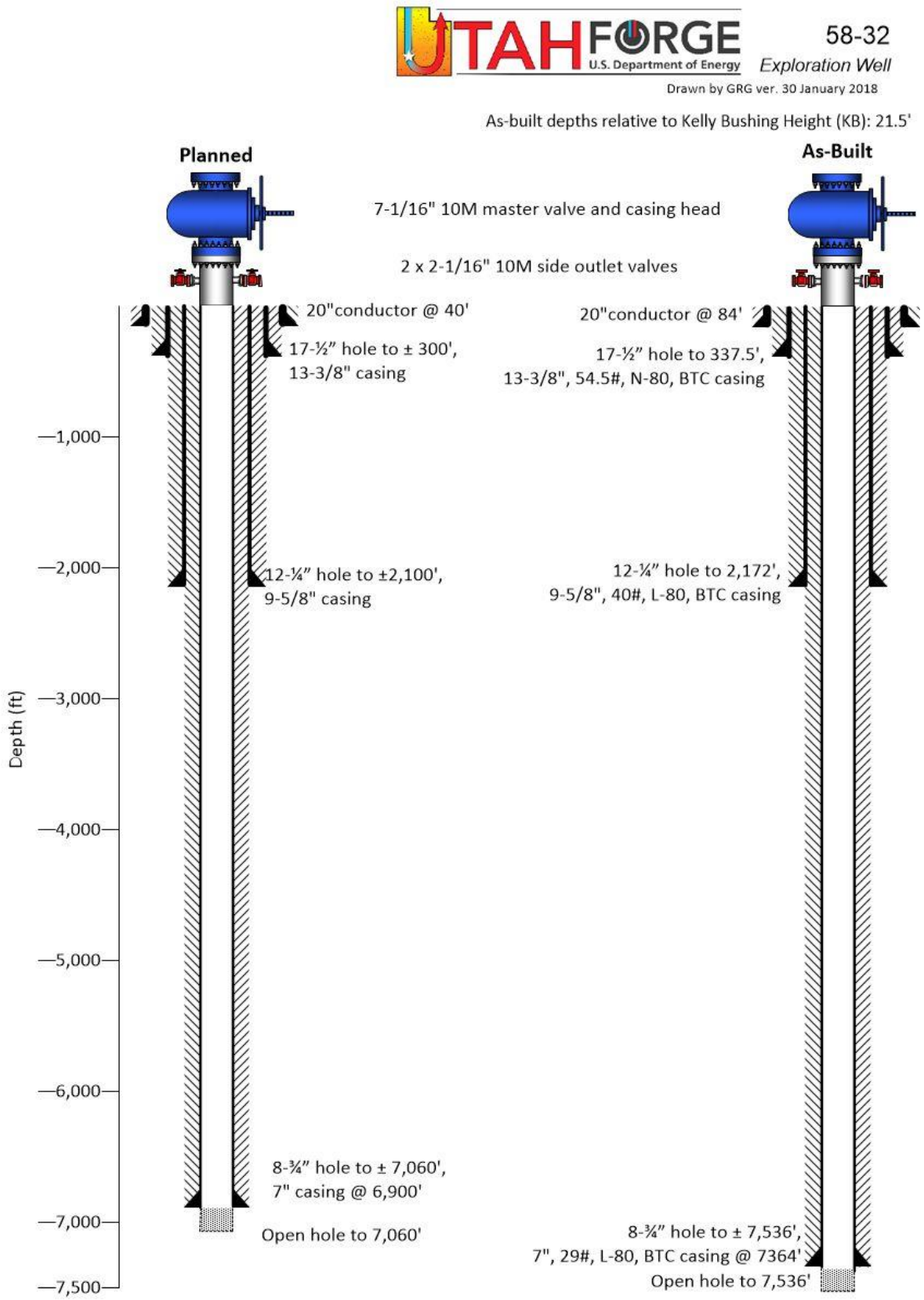


Figure 3: 58-32 planned and actual wellbore construction.

4.5. Days v. Depth

Well 58-32 was drilled to a total depth of 7,536', 476' deeper than the planned depth of 7,060' and in less time than anticipated (Figure 4). The expected rate of penetration (ROP) in the granitic formation was difficult to predict. Additionally, several types of bits were tested within the granitic section, which led to uneven penetration rate. Anomalous penetration rates are observed at several depths, and can be attributed to particular operations. Beginning at the top of the well, the initial 9-5/8" casing point at 342', the casing, cementing and nippling up of the wellhead and BOPE was completed in half the time expected. The drilling rates through the alluvium section to were faster than anticipated. Half the time was spent than anticipated at the 9-5/8" casing point at 2,172'. The initial drilling rate out of the 9-5/8" casing was the same as the section above, an average of about 30 ft/hr, which was unexpected, as the interpretation of the wellbore cuttings indicated that the granite formation had been reached. At 3187', the bit was torqueing, and the drill string stuck at the bit, but was recovered. At the surface, it was found that a piece of the sleeve stabilizer was missing. Fishing operations to recover this piece account for the 1.5-day delay at this depth. At 5,477' the BHA was pulled out of the hole to check tools and bit, explaining the decrease in penetration rate at this depth. A new BHA was run at 5,701' and 6,177', explaining the reduction in penetration rate at those depths. At 6,800', pressure temperature surveys were taken, and the well was allowed to heat up for several days in order to obtain multiple surveys to produce a prediction of the final heat up temperature at this depth. Also, at this depth a core sample was gathered. Additional time was spent on this activity, as the core barrel failed, requiring a fishing operation. Continued drilling to TD took another 7 days, including running in a new BHA at 7,200', and coring at 7,440'. The testing, including open hole geophysical logging, running and cementing of 7" casing to 7,375', cleaning out of the open hole, injection testing and secondary logging of the open hole took 11 days, as opposed to the 18 days that were planned for these operations. The rig was released on 24 September, the final daily drilling report was issued on 27 September.

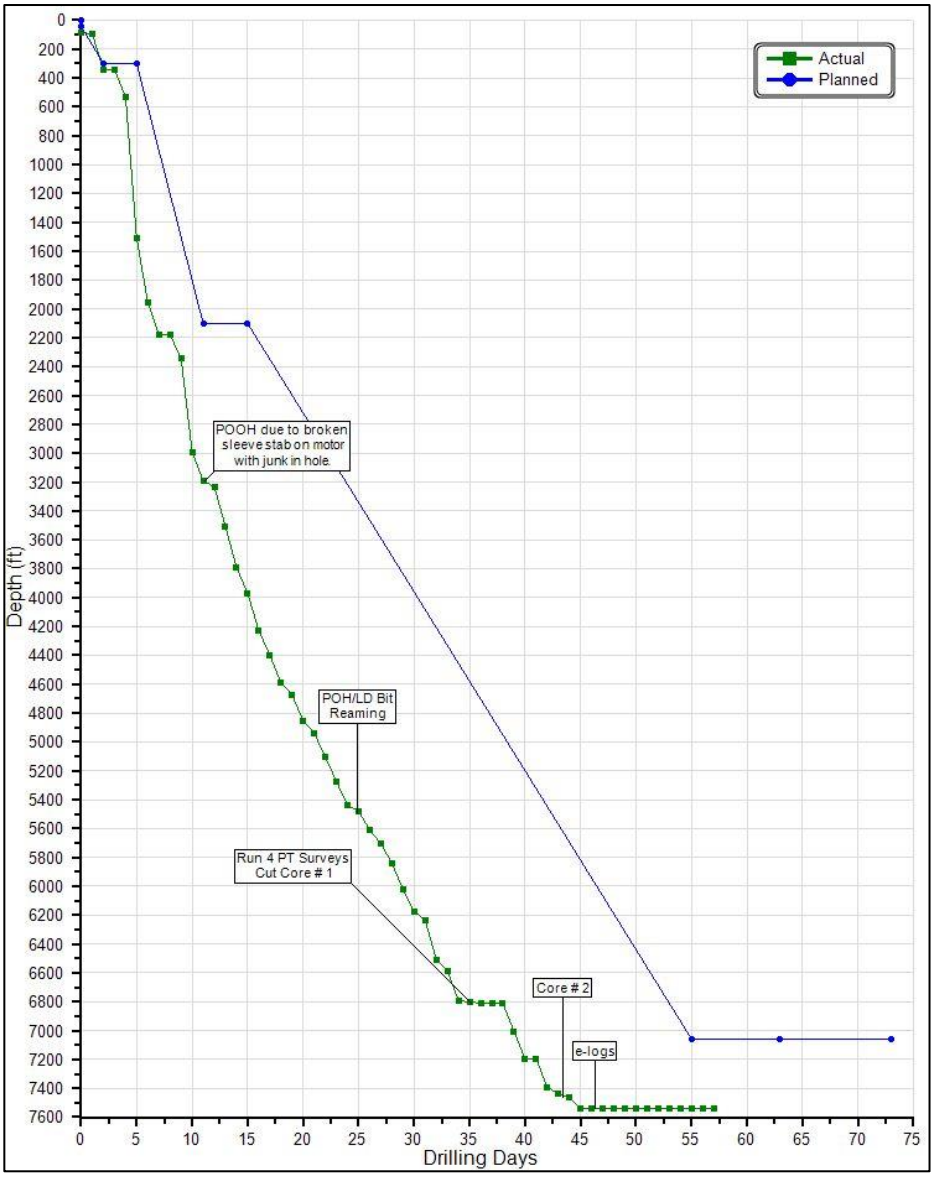


Figure 4: The planned and actual drilling Days versus Depth plots for well 58-23. The planned line was the "anticipated" days calculated and shown in Figure 3.

5. **Directional Program**

Well 58-32 was designed as a vertical well. In the top part of the well, magnetic single shot surveys were performed about every 300 ft, maintaining an inclination below 3° through the 12-1/4” section and below 5° in the 8-3/4” section. A mud motor was used below the 13-3/8” casing shoe at 2,180’ to maintain verticality. The survey results from surface to TD are shown in Table 5 the final calculated TMD is 7,530 ft. and TVD 7,521.8 is , as calculated by the directional drilling services provider. The final plot is shown in Figure 5.

Table 5: Survey data from magnetic survey shot (MSS) and measured while drilling (MWD) measurements for 58-32.

Survey Type	Meas. Depth (ft)	Inc. (deg)	Azimuth (deg)	TVD (ft)	Coordinates N-S (ft)	Coordinates E-W (ft)	Closure (ft)	Vertical Section (ft)	Dog Leg Severity (deg/100)
Wellbore:	**Original Well Bore**			**Plane of Vertical Section:**	**0**				
** TieIn	0.0	0.00	0	0.0	0.0	0.0		0.0	
MSS	278.0	0.30	20.59	278.0	0.7	0.3	0.7	0.7	0.108
MSS	582.0	0.30	205.9	582.0	0.7	0.2	0.7	0.7	0.197
MSS	868.0	0.40	1	868.0	1.0	-0.1	1.0	1.0	0.239
MSS	1,185.0	1.00	346	1,185.0	4.8	-0.8	4.9	4.8	0.196
MSS	1,471.0	1.00	347	1,470.9	9.7	-1.9	9.9	9.7	0.006
MSS	1,789.0	1.30	334	1,788.9	15.6	-4.1	16.2	15.6	0.124
MSS	2,138.0	1.90	24.5	2,137.7	24.4	-3.5	24.7	24.4	0.421
MSS	2,398.0	1.20	83.8	2,397.7	28.7	1.0	28.7	28.7	0.635
MSS	2,768.0	0.70	8.7	2,767.6	31.3	5.2	31.7	31.3	0.331
MMS	3,085.0	1.20	311.6	3,084.6	35.4	3.0	35.6	35.4	0.318
MMS	3,380.0	1.20	123.4	3,379.6	35.8	3.3	35.9	35.8	0.811
MMS	3,697.0	1.70	220	3,696.5	30.4	3.0	30.5	30.4	0.691
MMS	3,976.0	3.80	253.9	3,975.2	24.6	-8.5	26.0	24.6	0.921
MMS	4,293.0	6.30	255.8	4,290.9	17.4	-35.5	39.5	17.4	0.790
MMS	4,569.0	6.80	253.8	4,565.1	9.2	-65.8	66.5	9.2	0.199
MWD	4,603.0	7.56	272.33	4,598.9	8.7	-70.0	70.5	8.7	7.132
MWD	4,667.0	6.90	275.84	4,662.3	9.3	-78.0	78.6	9.3	1.240
MWD	4,739.0	6.95	272.2	4,733.8	9.9	-86.7	87.3	9.9	0.613
MWD	4,771.0	6.90	271.98	4,765.6	10.0	-90.5	91.1	10.0	0.177
MWD	4,803.0	7.21	271.45	4,797.3	10.1	-94.5	95.0	10.1	0.990
MWD	4,833.0	7.16	274.26	4,827.1	10.3	-98.2	98.8	10.3	1.183
MWD	4,865.0	6.68	276.37	4,858.9	10.7	-102.1	102.6	10.7	1.697
MWD	4,897.0	5.85	277.34	4,890.7	11.1	-105.5	106.1	11.1	2.615
MWD	4,928.0	5.27	278.13	4,921.5	11.5	-108.5	109.1	11.5	1.887
MWD	4,960.0	4.62	273.91	4,953.4	11.8	-111.2	111.9	11.8	2.326
MWD	4,992.0	3.82	265.82	4,985.3	11.8	-113.6	114.2	11.8	3.110
MWD	5,024.0	2.99	260.37	5,017.3	11.6	-115.5	116.1	11.6	2.781
MWD	5,055.0	2.11	250.53	5,048.2	11.2	-116.8	117.4	11.2	3.160
MWD	5,087.0	1.54	251.5	5,080.2	10.9	-117.8	118.3	10.9	1.784
MWD	5,119.0	1.76	267.32	5,112.2	10.8	-118.7	119.2	10.8	1.574
MWD	5,151.0	1.76	281.9	5,144.2	10.8	-119.6	120.1	10.8	1.396
MWD	5,183.0	1.63	295.97	5,176.2	11.1	-120.5	121.1	11.1	1.359
MWD	5,214.0	1.49	295.97	5,207.2	11.5	-121.3	121.8	11.5	0.452
MWD	5,246.0	1.01	277.51	5,239.2	11.7	-122.0	122.5	11.7	1.940
MWD	5,278.0	1.01	251.7	5,271.2	11.7	-122.5	123.1	11.7	1.410
MWD	5,310.0	1.49	241.83	5,303.2	11.4	-123.1	123.7	11.4	1.639
MWD	5,341.0	1.63	243.5	5,334.1	11.0	-123.9	124.4	11.0	0.475
MWD	5,373.0	1.27	231.37	5,366.1	10.6	-124.6	125.0	10.6	1.472
MWD	5,405.0	0.62	203.24	5,398.1	10.2	-124.9	125.3	10.2	2.438
MSS	5,679.0	0.70	136.6	5,672.1	7.6	-124.3	124.6	7.6	0.266
MSS	5,872.0	1.50	316.2	5,865.1	8.6	-125.3	125.6	8.6	1.140
MSS	6,062.0	1.80	346.6	6,055.0	13.3	-127.7	128.4	13.3	0.480
MSS	6,345.0	2.40	350	6,337.8	23.4	-129.8	131.9	23.4	0.216
MSS	6,478.0	2.50	334.9	6,470.7	28.8	-131.5	134.6	28.8	0.490
MSS	6,605.0	2.60	287.3	6,597.6	32.2	-135.4	139.2	32.2	1.622
MSS	6,730.0	3.80	274.1	6,722.4	33.3	-142.2	146.1	33.3	1.120
MWD	6,767.0	3.87	279.53	6,759.3	33.6	-144.7	148.5	33.6	0.999
MWD	6,798.0	4.18	276.37	6,790.2	33.9	-146.8	150.7	33.9	1.229
MWD	6,830.0	3.69	281.12	6,822.2	34.2	-149.0	152.9	34.2	1.838
MWD	6,862.0	3.12	280.59	6,854.1	34.6	-150.9	154.8	34.6	1.784
MWD	6,894.0	2.24	277.16	6,886.1	34.8	-152.4	156.3	34.8	2.794
MWD	6,926.0	1.58	265.03	6,918.1	34.9	-153.4	157.3	34.9	2.408
MWD	6,989.0	0.92	260.81	6,981.0	34.7	-154.8	158.6	34.7	1.057
MWD	7,021.0	1.14	281.2	7,013.0	34.7	-155.3	159.2	34.7	1.325
MWD	7,053.0	1.10	295.1	7,045.0	34.9	-155.9	159.8	34.9	0.856
MWD	7,084.0	1.19	276.11	7,076.0	35.1	-156.5	160.4	35.1	1.252
MWD	7,116.0	1.14	274.88	7,108.0	35.1	-157.2	161.1	35.1	0.175
MWD	7,357.0	1.80	274	7,348.9	35.6	-163.3	167.2	35.6	0.274
PROJ	7,530.0	2.30	273.5	7,521.8	36.0	-169.5	173.3	36.0	0.289

Calculations using Minimum Curvature Method

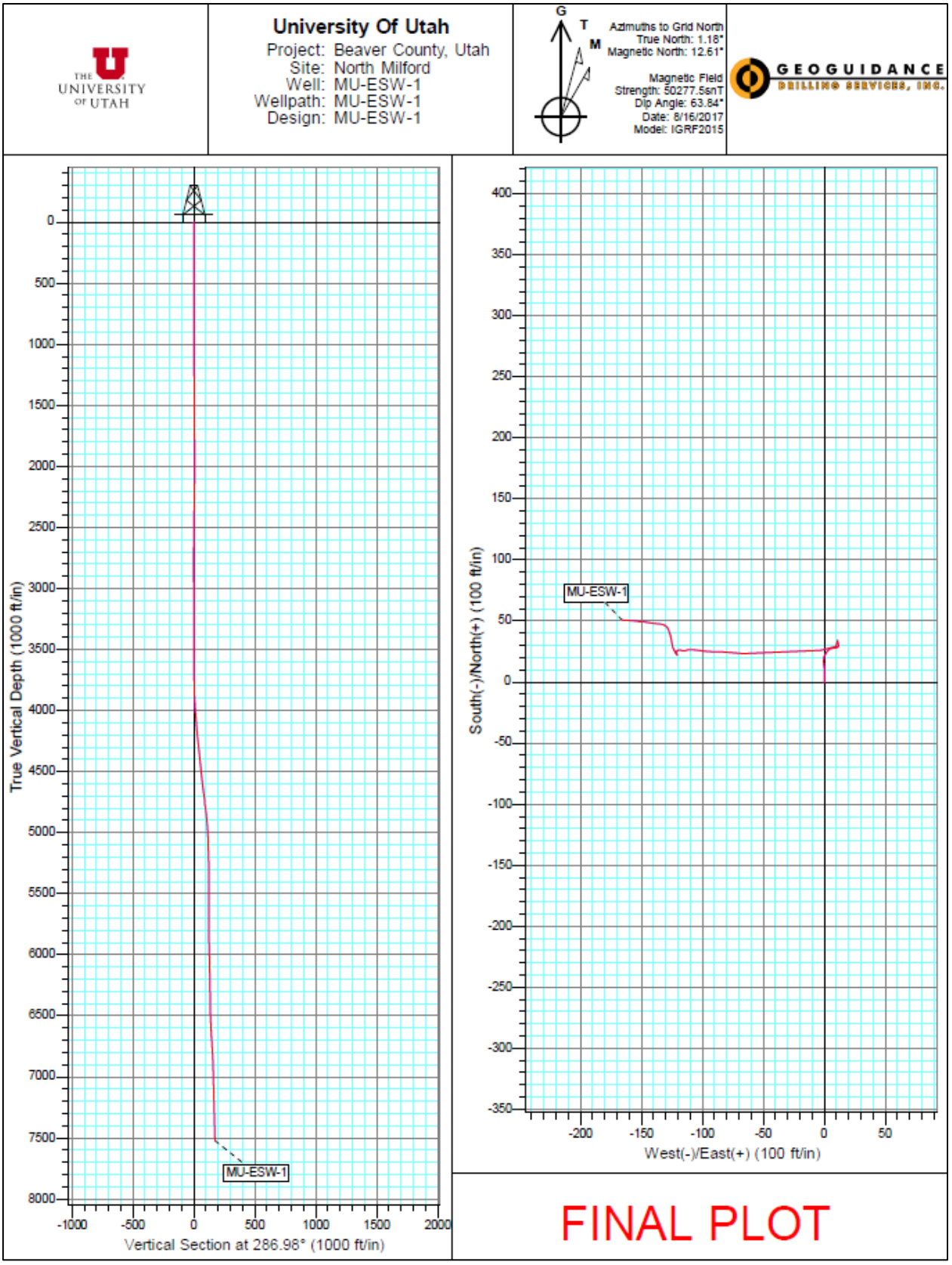


Figure 5: Final directional survey plot.

6. **Drilling activity by well section**

6.1. Mob, site prep, conductor

The pad was constructed by Rollins Construction Company improved and built the access road and began the pad construction at the end of June 2017. The pad dimensions are 250’ x 150’ with a sump size of 200’ x 50’ x 6’ sump. The pad grading and sump were completed after the conductor was installed. The cellar and conductor were installed over three days by Pete Martin Drilling, supervised by GRG Drilling Supervisor Virgil Welch. On 9 July 2017, the 36” conductor hole was drilled to 37’ bgl (Figure 6). The formation encountered was loose alluvium to 37’ BGL, which was poorly sorted clay to pebble size, reddish tan in color. Pictures of the loose alluvium samples were taken every 2-3’. On 10 July, the 10’ diameter cellar was installed, and the conductor was deepened to 62’ BGL, in a wet, clayey sand. The 20’, X-42, 52.7 ppf conductor was cemented with 10 cubic yards cement to 62’ bgl (Figure 7). A 18’ piece of the casing was added to the top of the conductor above the surface. On 11 July, a support frame was built over the cellar for the eventual support of the rig. The pad was completed with an additional 6” of base after the conductor was installed and sump was dug (Figure 8).

Figure 6: Drilling conductor hole to 37’.

Figure 7: Installation of conductor and mouse hole

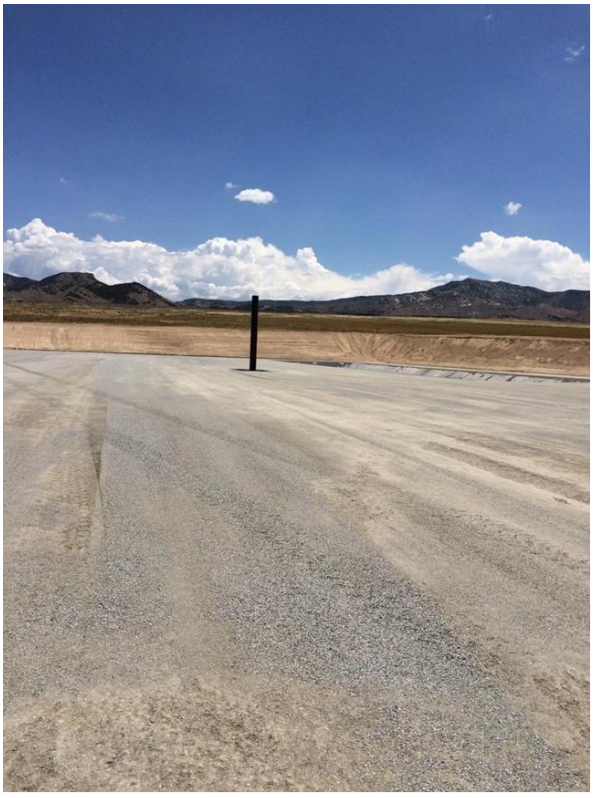


Figure 8: 58-32 pad as completed on 21 July 2017.

Kenai Rig 10 loads began arriving at the site on 27 July, rig up completed and then 24-hour

operations began on 31 July, spudding close to midnight from 84’ RKB. Image of the rig during drilling operations shown in Figure 9.

Figure 9: Rig site during drilling of 58-32.

6.2. 17-1/2” hole to 342’, 13-3/8” casing

6.2.1 Drilling objectives

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

- Drill 17-1/2” section from 20” conductor shoe at 83.5’ to the 13-3/8” casing shoe depth in a single bit run
- Case-off shallow unconsolidated formations, gas zones, and loss zones
- Drill to sufficient casing depth to install the BOPE
- Maintain vertical well bore within 1.5° and stabilize wellbore hazards

6.2.2 Summary

Drilling of the 17-1/2” hole began on 31 July from the bottom of the 20” conductor casing at 84’. Drilling to the casing point at 342’ was accomplished the next day, 1 August, without incident. The 13-3/8" 54.5#, N80, BTC casing was run to 337.51’. No circulation losses were

found in this section and the wellbore was within 0.3° at TD of section.

6.2.3 17-1/2" Surface Equipment

The 17-1/2" section was drilled using a flowline directly from a 20" riser welded to the conductor (Figure 10). No additional blow out prevention equipment (BOPE) was required for this section of the well.

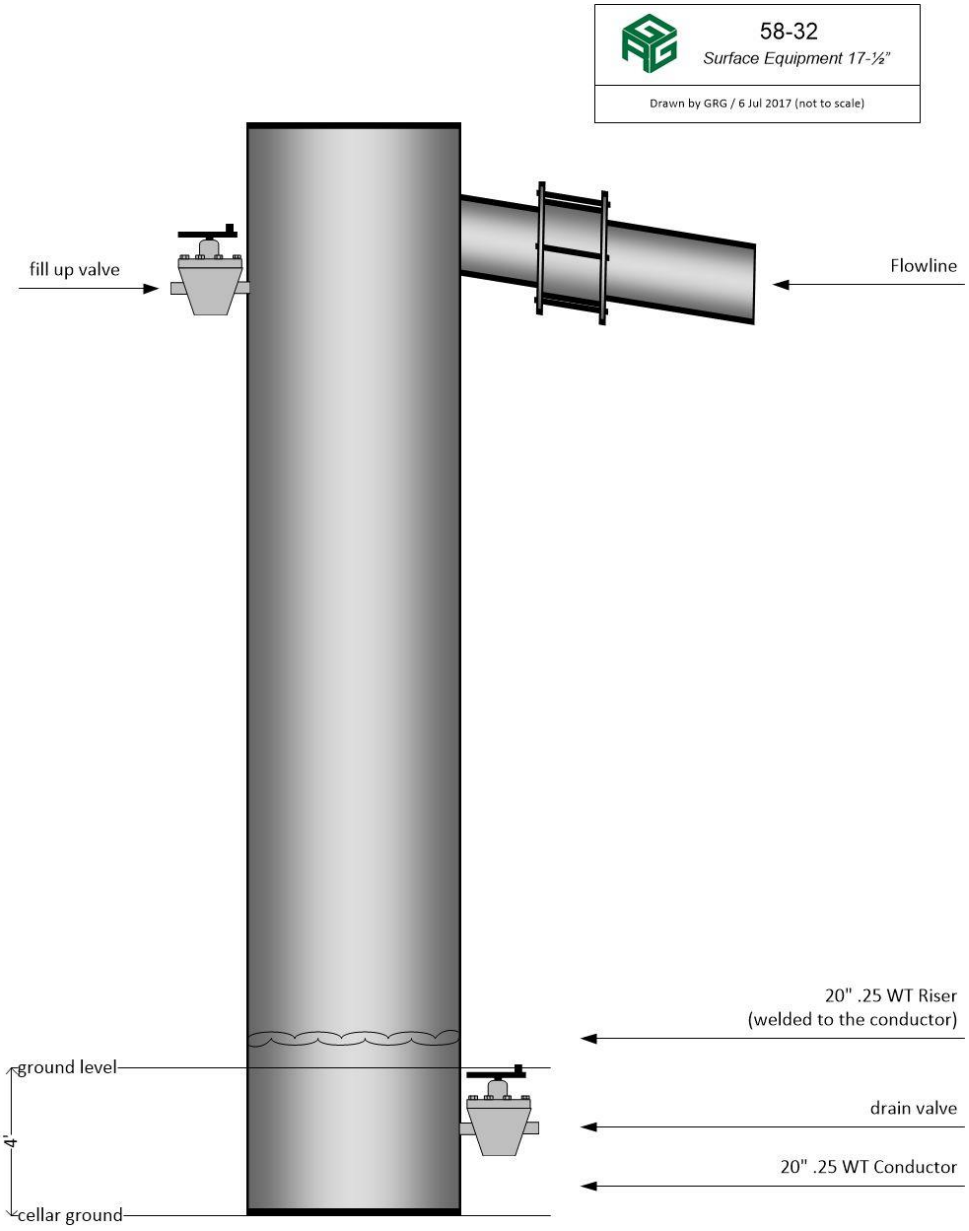


Figure 10: 20" conductor stack, used for drilling 17-1/2" hole.

6.2.4 17-1/2" Bit, Hydraulic program, and BHA

A 17-1/2" re-tipped rental mill tooth bit was used to drill the 17-1/2" section from 84' to 337'. The bit parameters and basic drilling parameters shown in Table 6 were used. Selections were made based on expected alluvium formation, relatively short section length, and shallow depth. The bottom hole assembly consisted of the bit, a near bit stabilizer, a non-magnetic drill collar,

a second stabilizer, a shock sub, two drill collars, a third stabilizer, two drill collars, jars, and two drill collars for a total length of 273’ (Figure 11).

Table 6: Basic drilling parameters for 17-1/2" 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)
1/1	258	17.5	114	10	60	18 18 24	750	21.5

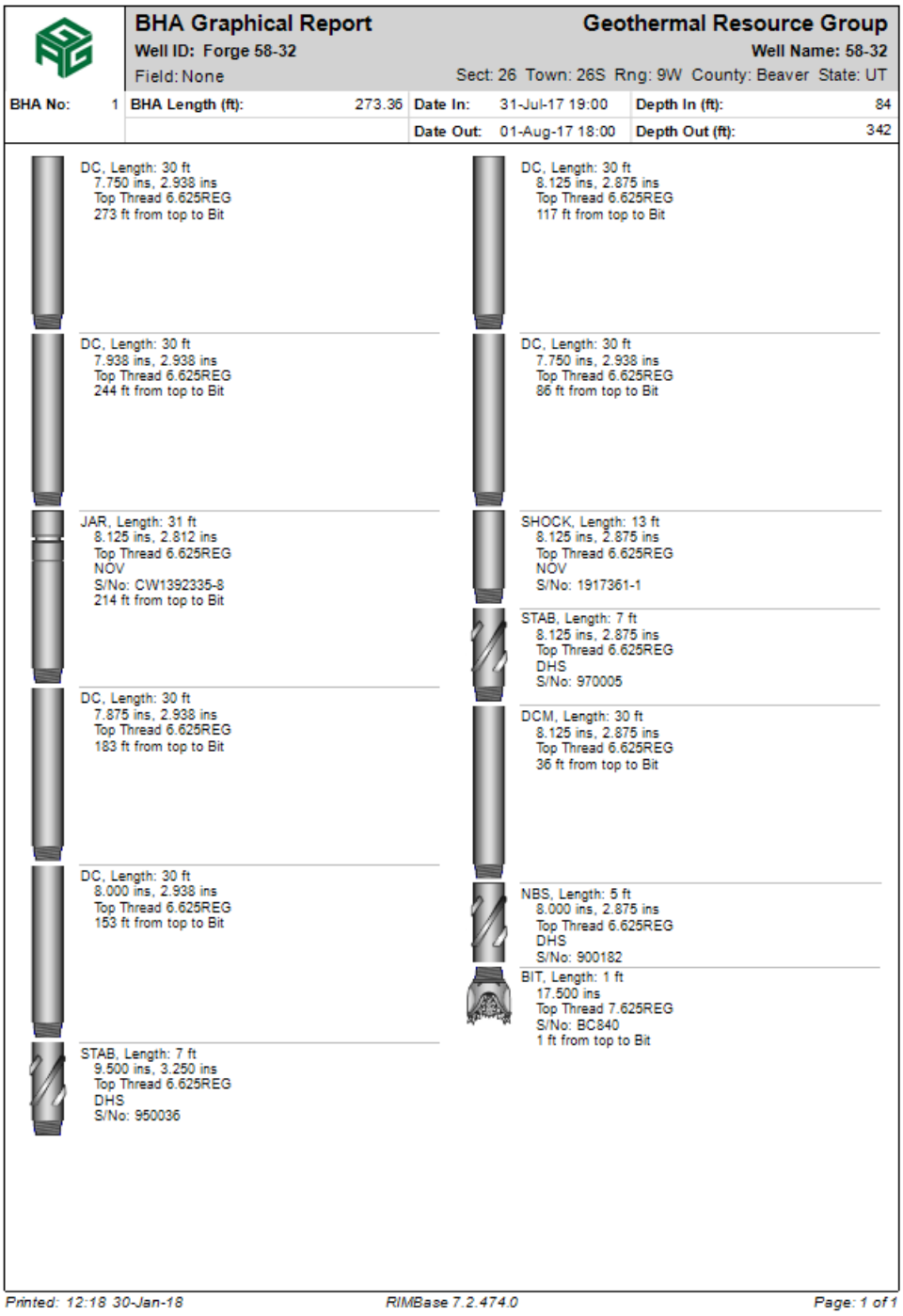


Figure 11: BHA used for drilling 17-1/2" hole.

6.2.5 17-1/2" Drilling fluids

The drilling fluid properties for the 17-1/2" section were maintained during drilling per the accepted detailed drilling fluids program (**Error! Reference source not found.**). 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. The alternative mud program for lost circulation was not used.

Table 7: Planned drilling conditions and fluid properties for 17-1/2" section.

INTERVAL I: 0 – 300'

1.	Hole size	: 17 ½"
2.	Casing size	: 13 3/8"
3.	Mud type	: Lime/Gel/Water System
4.	Total mud volume	: 400 bbls (300 bbls surface volume)
5.	Directional Program	: NA - Vertical Hole
6.	Formations	: Surface Alluvium
7.	Interval BHT	: <100°F

DEPTH (FT)	WEIGHT (PPG)	VISCOSITY (SEC)	FILTRATE (ML)
0-300'	8.6-9.2*	50-60+	<20

- Drill 17 ½" 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" casing.
- Mud Volume at 300': 400 bbl (100 bbl surface volume)
- Mud Additives and Concentrations:
  20+ ppb Bentonite/Gel; ~.5 ppb Soda Ash; Polyvis for sweeps; Desco CF

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

Fluid Parameters (spud)	Unit	Min	Max	Ave
Mud Weight	ppg	8.6	9.2	8.65
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" Casing and Cementing

The 13-3/8", 54.5 ppf, N-80 casing was set at 337.6', and cemented with centralizers at 327', 307', 260', 186', and 112'. The cement report is shown in (Figure 12). Top of cement fell to four feet below the cellar and was filled with gravel. After 5.5 hours waiting on cement, the 13-5/8" 3M x 5M clamp-on well head was installed and tested.

Cement Job Information			
Start Date/Time:	02-Aug-17 03:30	Wellbore:	Original Well Bore
Job Type:	PRIMARY	String OD (ins):	13.375
Well Section:	SURF	String Type:	FULL
Cementing Co:	Resource	Cementing Engineer:	Farzad Najafi

Primary Job Detail	Volume (bbls)	Pump Time	Rate (bbls/min)	Pressure (psi)
Conditioning Data:		90	6.0	200
Cement Data:	126.0	90	5.0	200
Displacement Data:	0.0			
Calc. Displacement Vol:				

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

Slurry Information						
Type	Density	Yield	Sacks	Volume	Rate	Additives
FLUSH	8.40			20.0	5.0	Fresh Water ahead
SPACER	10.50			30.0	5.0	Sepiolite spacer
SPACER	8.40			5.0	5.0	Fresh water spacer
FLUSH	10.00			13.6	5.0	Sodium Silicate
SPACER	5.00			5.0	5.0	Fresh water spacer
LEAD	13.00	2.5	170	83.0	5.0	ThermaLite cement with 3% calcium chloride
TAIL	15.00	1.78	130	43.0	4.6	ThermaTail cement with 3% calcium chloride

Post Job Information			
Liner Top Test (lbs/gal):		Job Success?	No
Actual Top of Cmt (ft):	4	CBL Bond Quality:	
Misc. Comments:	Had full returns during job. Did not have good cement to surface after pumping available cement. Pumped top job cement. Unable to displace DP (3.2 bbls). Found wiper plug stuck in cement head. Found cement when drained stack.		

Figure 12: Cement record for 13-3/8" casing.

6.3. 12-1/4" hole to 2,180', 9-5/8" casing

6.3.1 12-1/4" Hole Objectives

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

- Drill the cement inside the 13-3/8" shoe track (±40 ft) and 1,800 ± 500 ft of new hole from the 13- 3/8" casing shoe depth to 2,100 ± 450 ft. (13-3/8" casing shoe depth), in a single bit run
- Maintain vertical borehole within 3° and stabilize wellbore hazards
- Drill fast to reduce the wellbore exposure to the drilling fluid.

All of these objectives were achieved.

6.3.2 12-1/4" Summary

After 5.5 hours waiting on cement, the 13-5/8" clamp-on well head was installed and tested. After the BOPE was installed and tested, cement was tagged at 290', cleaned out to 342' and new hole was drilled to 360'. A Formation Integrity Test (FIT) gave a maximum allowable mud weight of 11.9 ppg for the next drilling section. The 12-1/4" vertical hole was drilled to 2,180 ft. between 3 and 6 August. The 9-5/8" casing was set at 2,172.4 ft. and cemented. No circulation losses, reactive clays or kicks were found in this section. The wellbore deviation was 1.9° at TD of section.

6.3.3 12-1/4" Surface Equipment

The BOPE used for the 12-3/4" drilling section is shown in (Figure 13), consisting of a 13-5/8" 5M double gate preventer and a 13-5/8" 5M annular preventer as the main elements. The equipment was function tested and witnessed by a Utah Department of Natural Resources

representative on 3 August.

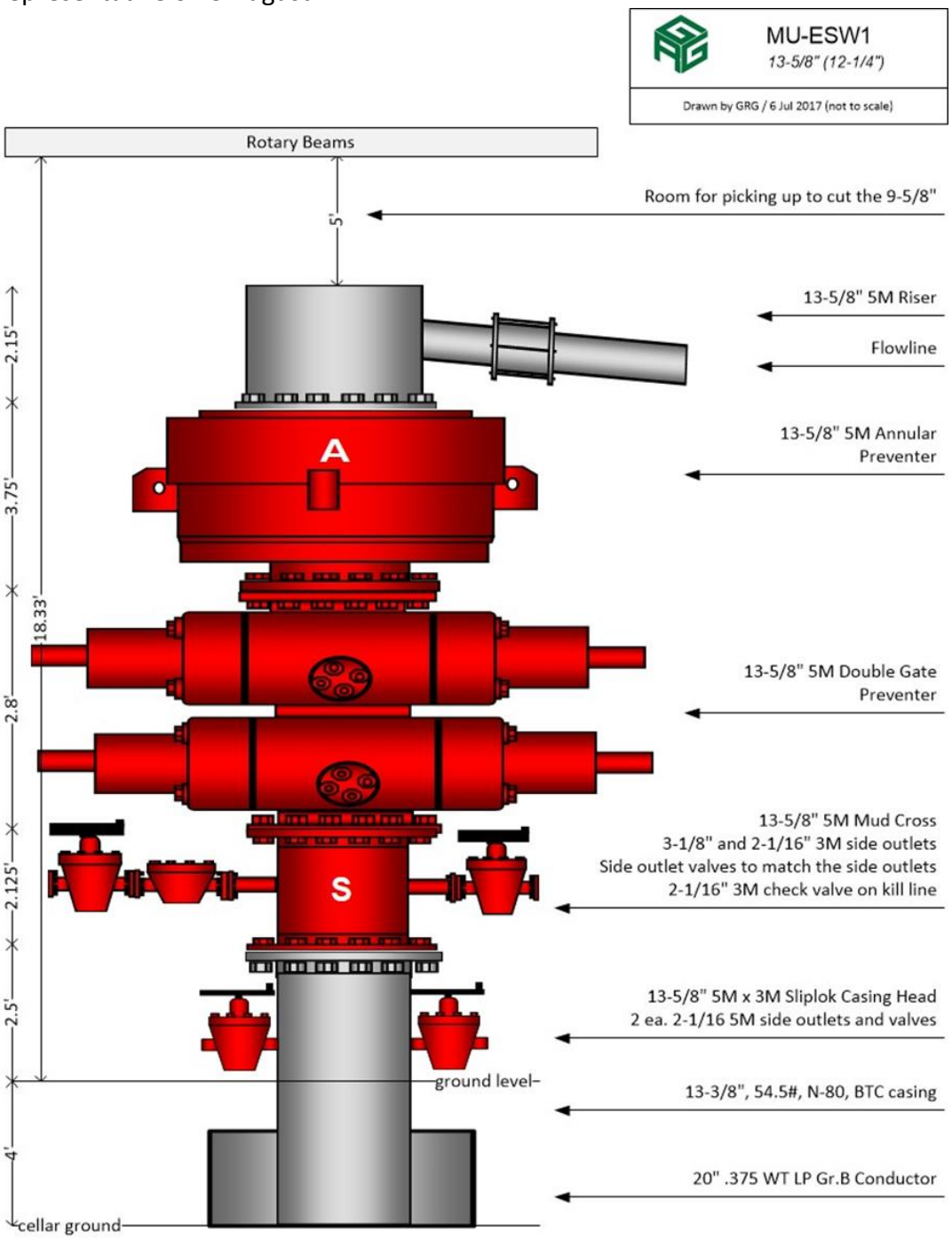


Figure 13: BOPE 13-5/8" for drilling 12-1/4" hole.

6.3.4 12-1/4" Bit, Hydraulic program and BHA

One bit was used through the 12-1/4" section, a Smith XR+ Milltooth bit, IADC Code 117, went in at 342 ft, and completed the 12-1/4" section to 2,180 ft. (1,838 ft.). Some of the bit

parameters are shown in Table 9. The remaining BHA is shown in Figure 14, a total of 582 ft.

Table 9: 12-1/4" 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	1838	12-1/4"	117	20	80	22 22 22	613	30.3

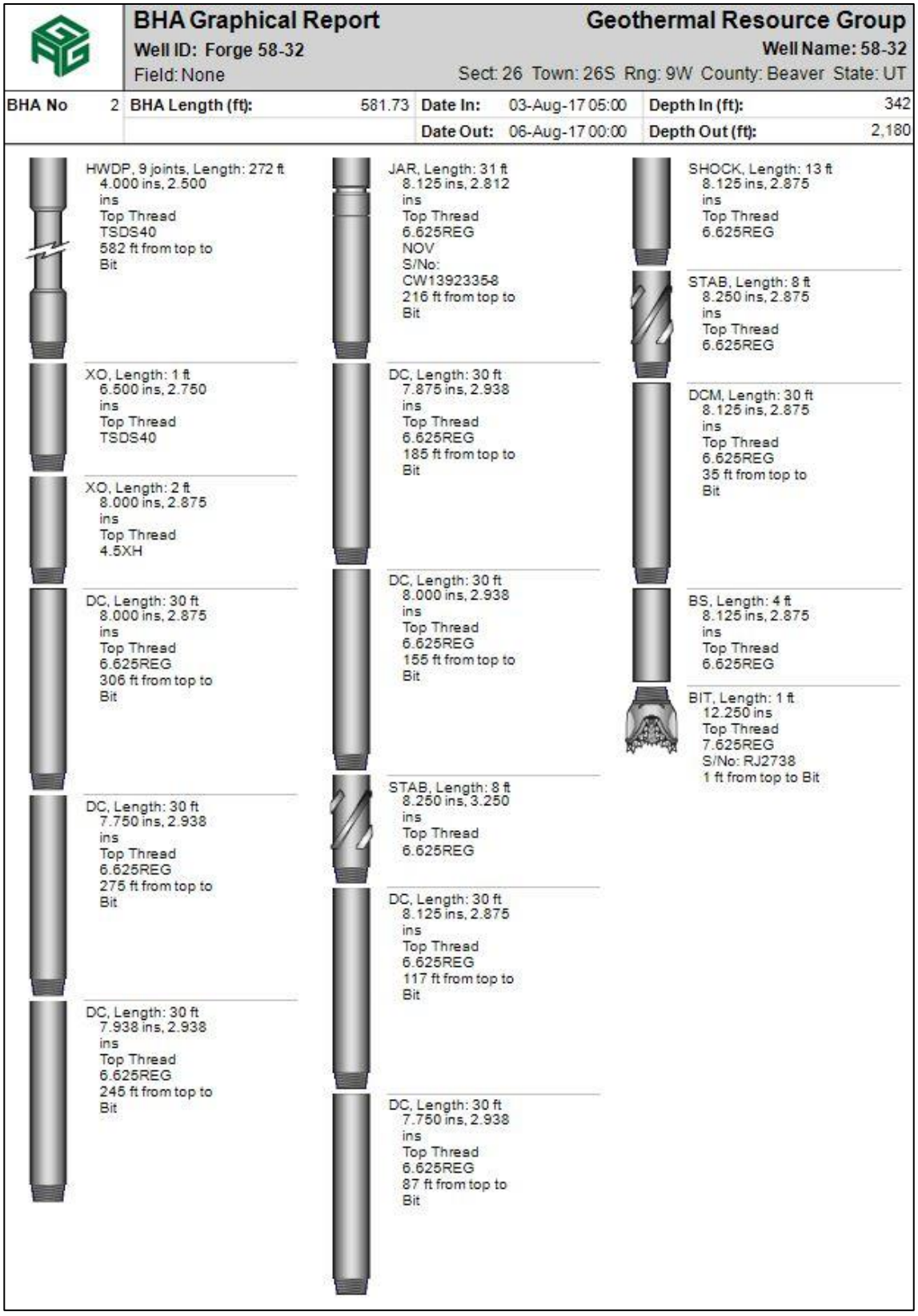


Figure 14: 12-1/4" BHA.

6.3.5 12-1/4" Drilling Fluids

Planned basic drilling parameters and the design of the mud system for the 12-1/4" drilling section are shown in Table 10. The drilling fluid parameters maintained in the 12-1/4" drilling section are shown in Table 11. It was designed as a Polymer mud system with a weight between 8.6 and 9.5 ppg, with minimal additives to minimize damage to any fractures encountered. A secondary plan was available if losses or hole instability were encountered, but this was not needed. Micronized cellulose was maintained at 3%.

Table 10: Planned basic drilling fluid parameters for the 12-1/4" drilling section.

INTERVAL II: 300'-2,100'

1.	Hole size	: 12 ¼"
2.	Casing size	: 9 5/8"
3.	Mud type	: HT Treated Gel/Water/Polymer System
4.	Total mud volume	: 850 bbls. (500 bbls surface volume)
5.	Directional Program	: NA – Vertical Hole
6.	Formations	: Surface Alluvium, Tuff, Top of Granite
7.	Interval BHT	: <200°F

DEPTH (FT)	WEIGHT (PPG)	VISCOSITY (SEC)	FILTRATE (ML)
300'- 2,100'	8.6-9.5*	45-60	<12

- Lightly dispersed Clay-based mud HT system; directionally drill 12 ¼" 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 10.0-10.5 with Caustic Soda. If encountered, control lost circulation with conventional LCM pills and drill cuttings. Run and cement 9 5/8" casing.
- Mud Volume at 2,100': 850 bbls (500 bbls surface volume)
- Mud Additives and Concentrations:
  15-20 ppb Bentonite/Gel; 2.0 ppb DMA; .5 ppb PAC Polymer; .125 Desco CF; 2 ppb Micro C for Wellbore Strengthening; Polyvis/Sawdust/LCM for sweeps; Bicarb, TORKease/Walnut for torque/drag/hole stability; conventional LCM if/as needed

Table 11: Drilling fluid properties for 12-1/4" section.

Fluid Parameters (spud)	Unit	Min	Max	Ave
Mud Weight	ppg	8.6	9.2	9
pH	pH	9	10.5	9.6
API Fluid Loss (Filtrate)	cc/30 sec.	8.8	13.2	10.1
Plastic Viscosity	cP	8	16	11.5
Yield Point	lb/100ft^2	18	24	21.5

6.3.6 9-5/8" Casing and Cementing

The 9-5/8", 40 ppf, K-55 casing was run on 7 August, with the shoe set at 2172', and cemented. The cement report is shown in (Figure 15). No top jobs were needed. After 7.25 hours waiting on cement, preparations for drilling the next drilling section were made.

Cement Job Information			
Start Date/Time:	07-Aug-17 11:00	**Wellbore:**	Original Well Bore
Job Type:	PRIMARY	**String OD (ins):**	9.625
Well Section:	INT1	**String Type:**	FULL
Cementing Co:	Resource	**Cementing Engineer:**	Hamid

Primary Job Detail				
	Volume (bbls)	**Pump Time**	**Rate (bbls/min)**	**Pressure (psi)**
Conditioning Data:		2	11.0	500
Cement Data:	252.0	34	11.0	700
Displacement Data:	139.0	71	8.0	1,100
Calc. Displacement Vol:	139.0			

☑ **Reciprocate Pipe?**	☐ **Batch Mix?**	☑ **Bump Plug?**		**Bump Pressure:**	1,700
Returns to Surface:	FULL	☑ **Cement at Surface?**		**Volume (bbls):**	1,100.0
Calc Top of Cement (ft):	0	**Excess (%):**	100.00%	**Avg. Hole Size (ins):**	18.000

Slurry Information						
Type	**Density**	**Yield**	**Sacks**	**Volume**	**Rate**	**Additives**
SPACER	8.30	1	0	30.0	5.0	fresh water
SPACER		1	0	20.0	5.0	RC mud clean
PREFLSH	11.00	1	0	13.0	5.0	Sodium silicate
SPACER	8.30	1	0	5.0	5.0	Fresh water
SPACER	10.50	1	0	30.0	5.0	Sepiolite Spacer
LEAD	13.50	2.14	600	228.7	5.0	Class G cement with 30% silica flour, 10% Microlite, 0.5% CFL-115,
TAIL	15.00	1.75	75	23.4	5.0	Class G cement with 30% silica flour, 10% Microlite, 0.5% CFL-115
DISPLACE	8.30	1	0	20.0	5.0	Fresh water
DISPLACE	9.10		0	138.7	5.0	Mud

Post Job Information			
Liner Top Test (lbs/gal):		**Job Success?**	Yes
Actual Top of Cmt (ft):	0	**CBL Bond Quality:**	

Misc. Comments: Held JSA, Pressure test lines to 1500 psi, pump 30 bbls of fresh water @ 5 BPM, pump 20 bbl of RC MUD Clean @ 5 BPM, pump 13 bbls of Sodium Slicate spacer @ 3 BPM, pump 5 bbls of fresh water @ 5 BPM, pump 30 bbls of 10.5ppg Sepiolite spacer @ 5 BPM, mix and pump 228.7 bbls (1284 cu ft) of 13.5 ppg RC Thermalite HT lead cement w 30% silica flour, 10% micro slica, 0.5% CFL-115, followed by 23.4 bbls (131 cu ft) of 15.0 RC Thermalite HT tail cement w/30% silica flour, 10% micro Lite, 0.5% CPL-15 @ 5 BPM, shut down and dropped plug Our displacement was 158. bbls. 138 bbl mud and 20 bbl water We displaced 100 bbls @ 8 BPM and slowed displacement to 1 BPM for the next 18 min until 118 bbl was displaced, while pumping 1 BPM returns came and went. We then shut down for 20 minuets (to allow for gelling) and checked fluid level in the wellbore until it stopped dropping. Then displaced the last 20 bbls at 2 BPM with 100% returns and bumped the plug with 750 psi over the 1100 psi pump pressure. Bled back the pressure and confirmed the floats were holding. CIP was 12:45 . The BOP stack was drained @ 1500 hours and there is solid cement to the wellhead

Figure 15: Cement job report for 9-5/8" casing.

6.4. 8-3/4" hole to 7,536', 7" liner to 7,378'

6.4.1. 8-3/4" Objectives

Drilling objectives for this section of the well were:

- Drill the cement inside the 9-5/8" shoe track (±80 ft) and 5,000 ft of new hole from the 9-5/8" casing shoe to 7,060 ±450 ft. in 3 bit trips

- Maintain the well bore within 5° and stabilize wellbore hazards
- Drill fast to reduce wellbore exposure
- Penetrate the reservoir test section
- Preserve the reservoir test section by minimizing mud additives that may damage the formation
- Drill fast to reduce wellbore exposure to the drilling fluid

The objectives of the drilling program were achieved.

6.4.2. 8-3/4" Summary

The drilling of the 8-3/4" hole commenced on 8 August, and total depth of 7,536 ft. was reached on 14 September. Ten 8 ¾" bits were required due to the hardness of the formation. In some sections of the well the inclination was as high as 8°, particularly around 4,600 ft., but it was corrected by using directional tools and at TD, the final inclination was 1.8°. Two cores for a total of 35 ft. from two locations, one at 6,800 ft. and the second at 7,440 ft., were collected as part of the drilling program. A full suite of geophysical open hole logs were run by Schlumberger in the 8-3/4" section. Pressure and temperature surveys were performed at 6800'. Additionally, an acoustic image log was performed in the 8-3/4" hole from the bottom of the 9-5/8" casing to TD. After the drilling was completed, 7" blank casing was cemented to 7,375'. The bottom 161' of the hole was cleaned and left open to be tested.

6.4.3. 8-3/4" Surface Equipment

The 9-5/8" casing was cut off and the 8-3/4" surface BOPE equipment used was the same as used for the 12.25" section, using a 13-5/8" 5M x 3M Sliplock Casing Head, for fast assembly (Figure 16). The annular preventer and pipe rams were tested prior to running in the hole. A FIT was performed 5" drilled into formation, giving a maximum allowable mud weight of 19.23 ppg.

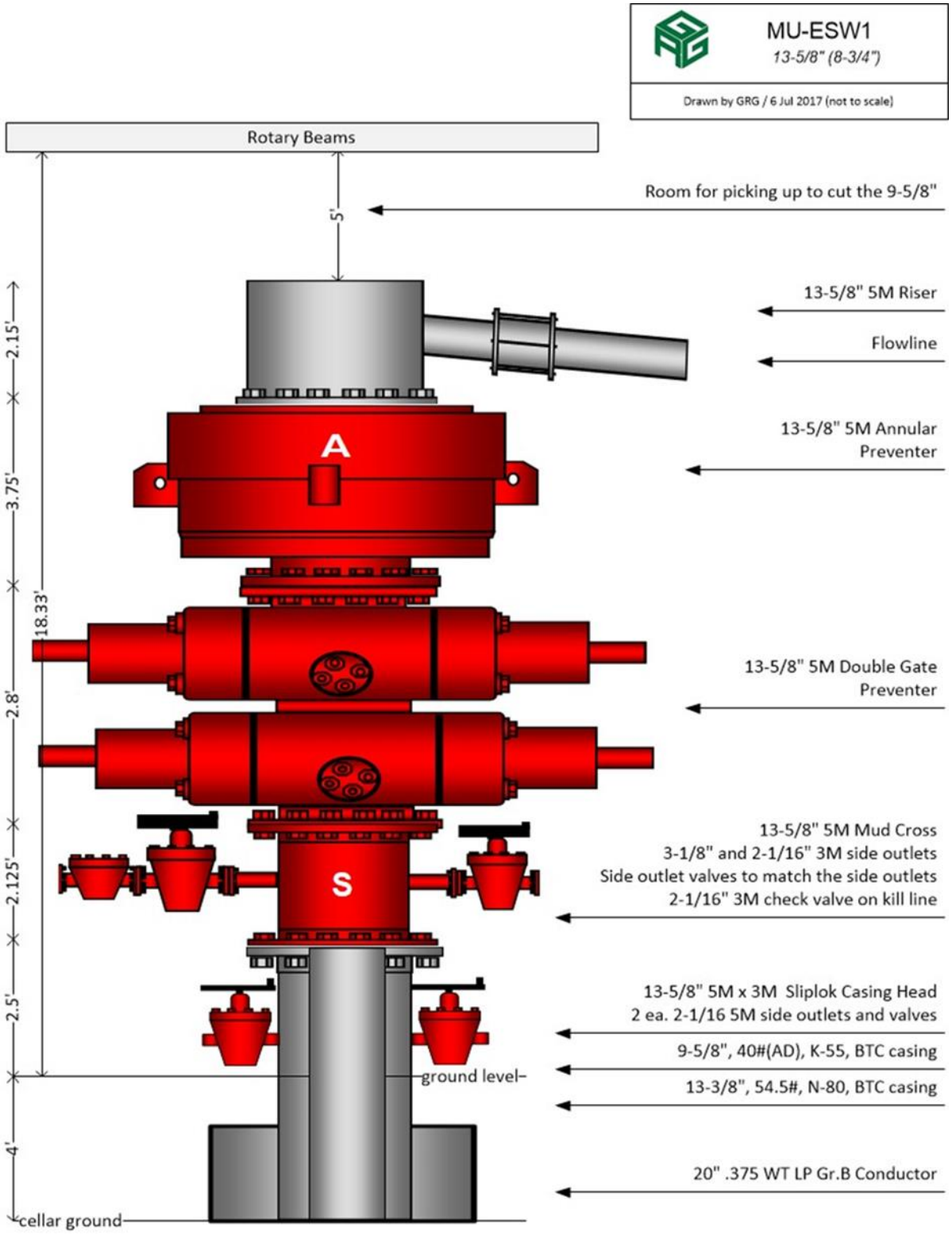


Figure 16: BOPE stack for drilling 8-3/4" hole.

6.4.4. 8-3/4" Bits, Hydraulic program and BHA

In the 17-1/2” section, the primary formation was granite, and a selection of bits were used through the section to test their performance. After the 7” casing was run, a 6” bit was run to clean out the open hole section to 7525’. The core bits used for the cored section are captured in Table 12 , along with the other bits used.

Table 12: Bits used in drilling the 8.75" 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)
3/1	1007	8.75	527	25	190	20 20 20	499	28
3/2	94	8.75	527	20	25	20 20 20	535	16.3
4/1	680	8.75	537	25	190	20 20 20	510	13.7
5/1	83	8.75	HYB	20	192	18 18 18 18	508	15.1
5/2	348	8.75	HYB	22	190	18 18 18 18	510	15.5
5/3	238	8.75	HYB	20	190	18 18 18 18	508	4.7
6/1	245	8.75	n/a string blade	20	114	13 13 13 13 13 13 13	394	7.8
6/2	248	8.75	n/a string blade	35	182	13 13 13 13 13 13 13	492	8.7
7/1	602	8.75	627	30	130	24 24 24	430	7.3
8/1	231	8.75	547	30	90	20 20 20	450	7.3
9/1	469	8.75	627	35	155	18 18 18	414	8.7
10/1	647	8.75	647	35	160	18 18 18	414	11.7
11/1	13	8.5	Diamond Impregnated Core bit	14	85	n/a	209	1.3
12/1	388	8.75	647	25	124	18 18 18	430	9.6
13/1	240	8.75	647	30	160	18 18 18	435	10.4
13/2	76	8.75	647	30	160	18 18 18	435	13.8
14/1	20	8.5	Core (MCP481)	30	160	N/A	435	13.8
15/1	444	6	117	12	60	32 32 32	435	74
15/2	117	6	117	7	60	32 32 32	450	80.5

6.4.5. 8-3/4” Drilling Fluids

Planned basic drilling and drilling fluid parameters used for the design of the mud system for the 8-3/4" drilling section are shown in Table 13. The actual average mud properties through the 8-3/4” section are given in Table 14. A secondary plan was available if losses or hole instability were encountered, but this was not needed. Micronized cellulose was maintained at 3%.

Table 13: Planned basic drilling and fluid parameters used for the mud system for the 8-3/4" drilling section.

INTERVAL III: 2,100'-7,060'

1.	Hole size	: 8 ¾"
2.	Casing size	: 7" (@ 6,900'); 160' barefoot for inj. test
3.	Mud type	: Water with viscous sweeps through production zone (non-damaging additives only). Cold water and/or weighted brines if/as needed for hydrostatic control
4.	Total mud volume	: 1,000 bbls. (600 bbls surface volume)
5.	Directional Program	: NA – Vertical Hole
6.	Formations	: Granite-Gneiss
7.	Interval BHT	: ~375°F

DEPTH (FT)	WEIGHT (PPG)	VISCOSITY (SEC)	FILTRATE (ML)
2,100'– 7,060'	8.4-9.0*	27/Sweeps	NC

Continue drilling 8 ¾" hole, discontinuing the use of Bentonite and other potentially damaging additives. Drill ahead with fresh water. Use viscous polymer sweeps consisting of Xanthan Gum/Diutan/Polyvis and Altavert 102 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 10.0-11.0 with Caustic Soda, consider Sinclair's K-Sub for wellbore inhibition and corrosion protection, 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.

- Mud Volume at 7,060': 1,000 bbls (600 bbls surface volume)
- Mud Additives and Concentrations:
  Water; Xanthan Gum/Diutan/Polyvis, AltaVert 102 for sweeps; .5ppb Caustic Soda; Micro C, Ctns Hulls, Sawdust for massive losses; TORKease for torque/drag/hole stability; corrosion inhibitors

Run and cement 7" casing to 6,900', move in testing rig and proceed with mini-frac testing. Viscous sweeps may be needed to clean the hole prior to frac testing.

Table 14: Mud parameters maintained while drilling 8-3/4" section

Fluid Parameters (spud)	Unit	Min	Max	Ave
Mud Weight	ppg	8.6	9.2	9
pH	pH	9	10.5	9.6
API Fluid Loss (Filtrate)	cc/30 sec.	8.8	13.2	10.1
Plastic Viscosity	cP	8	16	11.5
Yield Point	lb/100ft^2	18	24	21.5

6.4.6. 7" Casing and Cementing

Upon reaching TD, a suite of geophysical logs was run, then a 10 ft. cement plug was placed on the bottom and gravel was used to fill the hole from 7,525' to 7,860'. The 7" 29 ppf L-80 casing was run and cemented with the shoe set at 7375' on 16 September. The cementing report is provided in Figure 17.

Cement Job Information			
Start Date/Time:	17-Sep-17 04:00	**Wellbore:**	Original Well Bore
Job Type:	PRIMARY	**String OD (ins):**	7.000
Well Section:	PROD	**String Type:**	FULL
Cementing Co:	Resource	**Cementing Engineer:**	Farzad Najafi

Primary Job Detail				
	Volume (bbls)	**Pump Time**	**Rate (bbls/min)**	**Pressure (psi)**
Conditioning Data:		120	6.0	233
Cement Data:	317.0	63	5.0	
Displacement Data:	271.0	55	5.0	2,200
Calc. Displacement Vol:	271.0			

☐ **Reciprocate Pipe?**	☐ **Batch Mix?**	☑ **Bump Plug?**		**Bump Pressure:**	5,000
Returns to Surface:	FULL	☑ **Cement at Surface?**		**Volume (bbls):**	60.0
Calc Top of Cement (ft):	0	**Excess (%):**	100.00%	**Avg. Hole Size (ins):**	8.750

Slurry Information

Type	Density	Yield	Sacks	Volume	Rate	Additives
PREFLSH	8.33			50.0	5.0	Water ahead
PREFLSH	8.33			30.0	5.0	Foamed water
FLUSH	11.00			13.0	3.0	FoamedvSodium silicate
SPACER	8.33			5.0	5.0	Foamed water.
LEAD	13.50	2.14	750	284.0	5.5	Foamed Lead Cement 11 ppg foamed
TAIL	15.00	1.75	90	28.0	4.0	Cement, Not foamed.
TAIL	15.00	1.75	25	5.0	2.0	ECP cement behind plug.
POSTFLSH	8.33			271.0	6.0	Water behind.

Post Job Information			
Liner Top Test (lbs/gal):		**Job Success?**	Yes
Actual Top of Cmt (ft):	0	**CBL Bond Quality:**	
Misc. Comments:			

Figure 17: 7" cementing report.

6.4.7. Completion

The final testing wellhead and BOPE were installed after 9 hours waiting on cement (Figure 18). A 6” bit, casing scraper, bit sub and 4-3/4” drill collars, and 3 stands of heavy weight drill pipe (Figure 19) were used to clean out cement to 7,364 ft. in preparation for a cement bond log, which was run by Schlumberger, keeping the casing under pressure. Following this, the same BHA with a 6” bit was used to clean out cement in the casing and the gravel from 7,375 ft to 7,525 ft. Following this, open ended drill pipe was run to reverse circulate the gravel out from 7,525 ft. Then the well was turned over to water in preparation for testing. After operations were completed the wellhead was left with a 7-1/16” 10 M master valve, two 7-1/16” 10M side outlet valves below ground level, and a 3-1/16” 10M crown valve above the master valve (Figure 20).

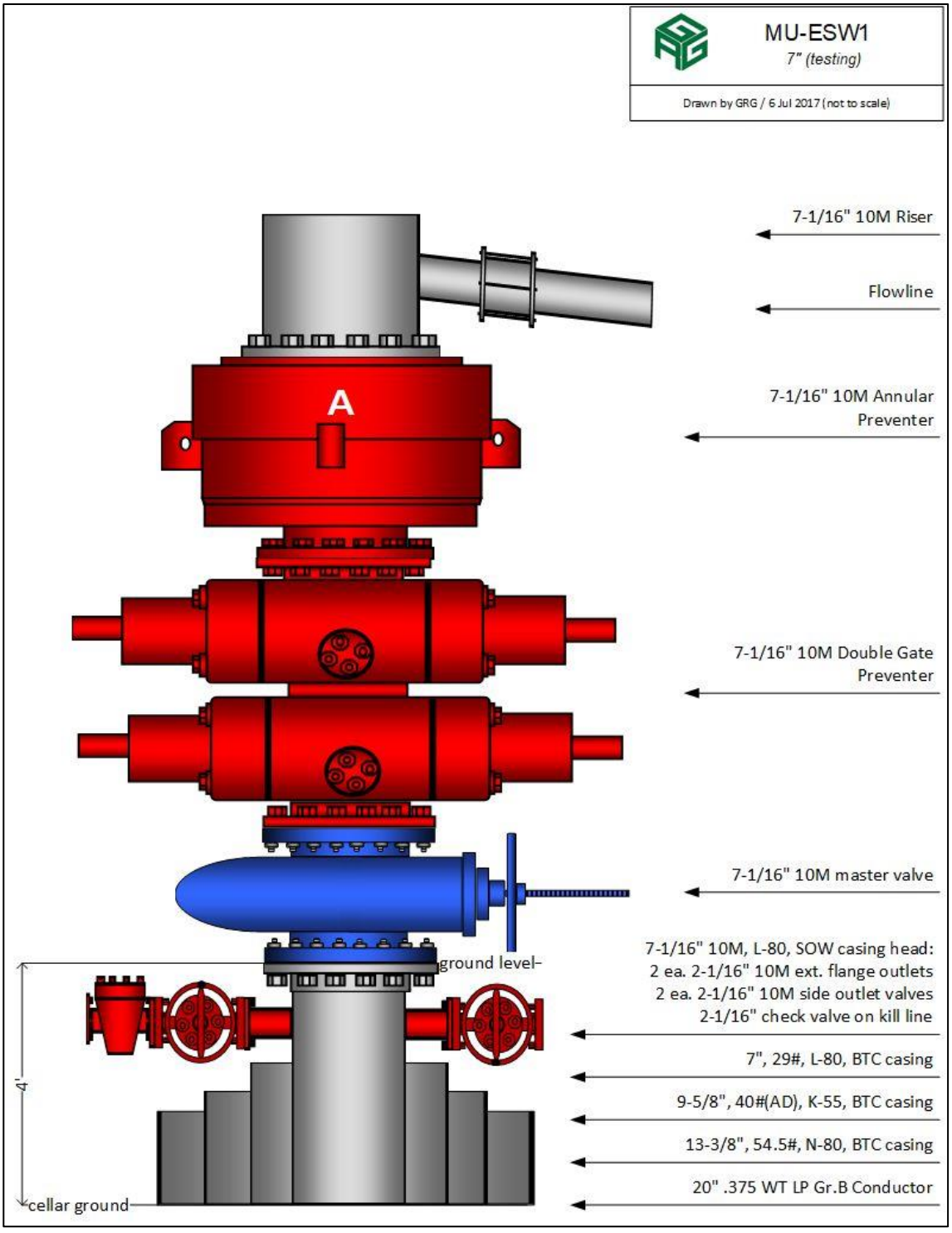


Figure 18: Wellhead and BOPE used for the final completion and testing of 58-32.

BHA No	22	BHA Length (ft):	187.95	Date In:	20-Sep-17 10:00	Depth In (ft):	7,364
				Date Out:	20-Sep-17 23:30	Depth Out (ft):	7,525

HWDP, 3 joints, Length: 91 ft
4.000 ins, 2.563 ins
Top Thread 3.5IF
188 ft from top to Bit

DCS, 3 joints, Length: 90 ft
4.750 ins, 2.500 ins
Top Thread 3.5IF
97 ft from top to Bit

BS, Length: 2 ft
4.875 ins, 1.750 ins
Top Thread 3.5IF
7 ft from top to Bit

SCRAP, Length: 4 ft
4.375 ins, 1.250 ins
Top Thread 3.5IF
4 ft from top to Bit

BIT, Length: 1 ft
6.000 ins
Top Thread 3.5REG
S/No: 835850
1 ft from top to Bit

Figure 19: 6" BHA for cleanout.

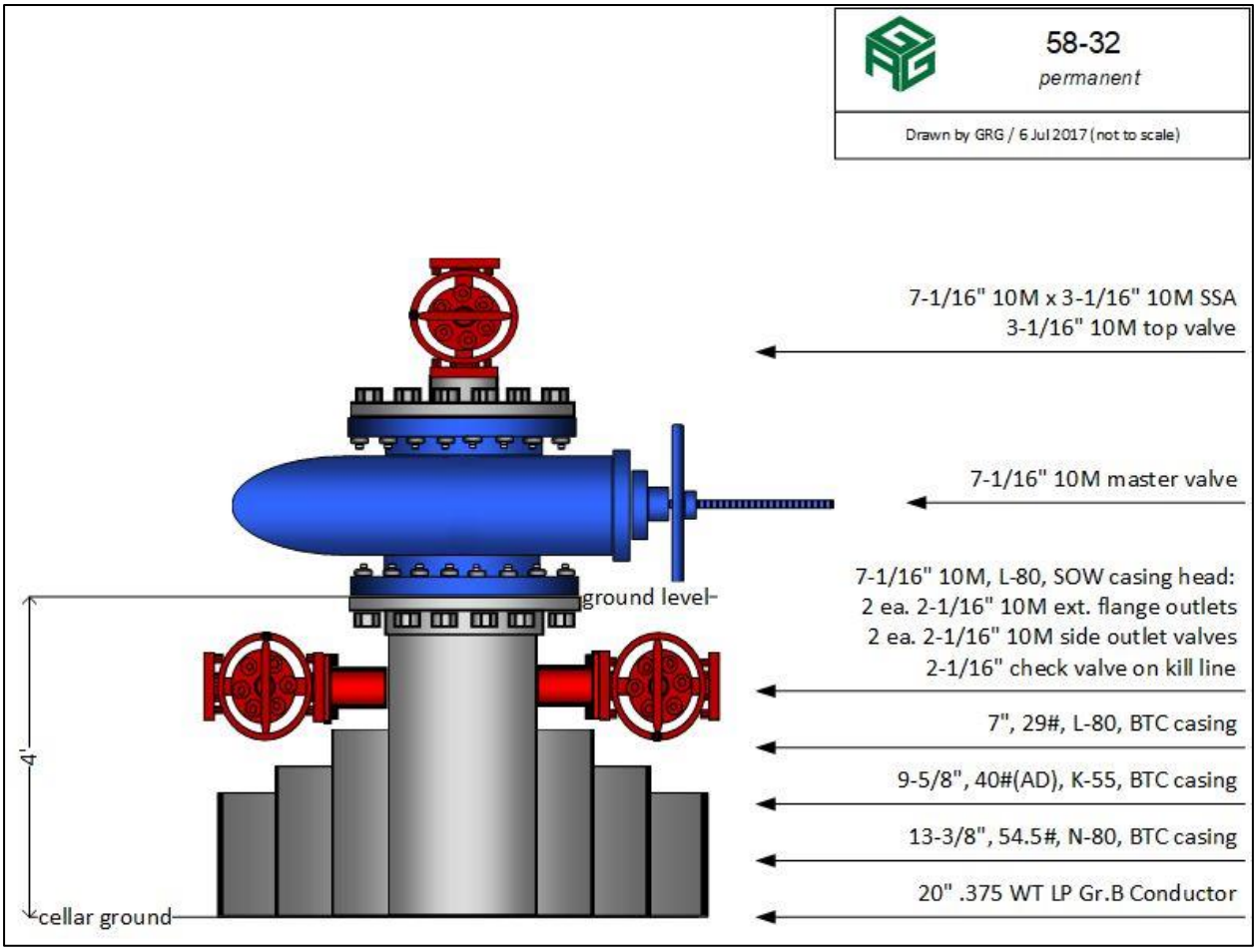


Figure 20: Final wellhead installed at 58-32.

7. Geologic Results

A mud logging service, West Coast Geologic, provided rig instrumentation as well as cuttings sample collection on a 24-hour basis during drilling. Samples were taken at 10 ft intervals and described. Reports were provided on a daily basis with cutting descriptions, and graphical representation of drilling data such as rate of penetration, weight on bit, mud flow temperatures in and out, circulation volume and rate, survey azimuth and angle, and casing setting depths. This log is provided in appendices. A summary of interpreted lithologies from the mud log and geophysical log results are given in Table 15.

Table 15: Summary of lithologies encountered.

Lithology	Thickness (ft)		Age	Description
	Actual	Cum.		

Alluvium	3,176	3,176	Quaternary/Tertiary	Alluvium comprised primarily of fine to coarse-grained granitic fragments.
Rhyolite	20	3,196	Tertiary	Fine-grained rhyolite with trace of quartz phenocrysts. Sheared, brecciated and devitrified.
Granite	4,340	7,536	Tertiary	Granitic rocks of variable composition mainly granite, quartz monzonite and monzodiorite

8. **Coring**

Core was taken at two depths in well 58-32, with services provided by ALS Reservoir Group Coring Services. Core recovery averaged 70.6% over the two runs. The core sample from run 2 was noted to be quite fractured while the core from Run 1 was more cemented.

8.1. Core Run 1

The first core was taken at 6800'. The BHA used for this core run is shown in Figure 21. The MCI 905 core head was selected for use based on the lithology predicted in the drilling prognosis. It is recommended for use in hard and/or abrasive formations with high to very high compressive strengths, high to very high cementation and abrasiveness.

When tripping in with the coring BHA, one foot of fill needed to be washed/circulated out to establish bottom. The initial core run began with 55 RPM and 4Klbs WOB. After establishing bottom, the parameters were increased to 80 RPM and 12Klbs WOB which achieved an average ROP of 1.4 ft/hr over the entire run.

At about 6,807 ft (7 ft. into Run 1), a torque spiked causing the rotary to stall out. The string was picked up to decrease the WOB and allow the rotary to stabilize. At this point there was an immediate surface pressure drop of about 150 psi. It continued to fall another approximately 50 psi before becoming erratic, trending back up into the original range. This pressure fluctuation was possibly caused by fluid seepage through a damaged stabilizer connection that was discovered when the BHA came to surface.

Run 1 was terminated when the ROP dropped off to 0.5 ft/hr and then made no advancement of the hole for 30 minutes. When the core barrel was tripped to surface, it was found that the pin connection of the stabilizer in the middle position of the coring assembly had failed. The inner barrel was intact and nothing abnormal was noted. The top two stabilizers did sustain considerable damage. A total of 10.6 ft. of core was recovered.

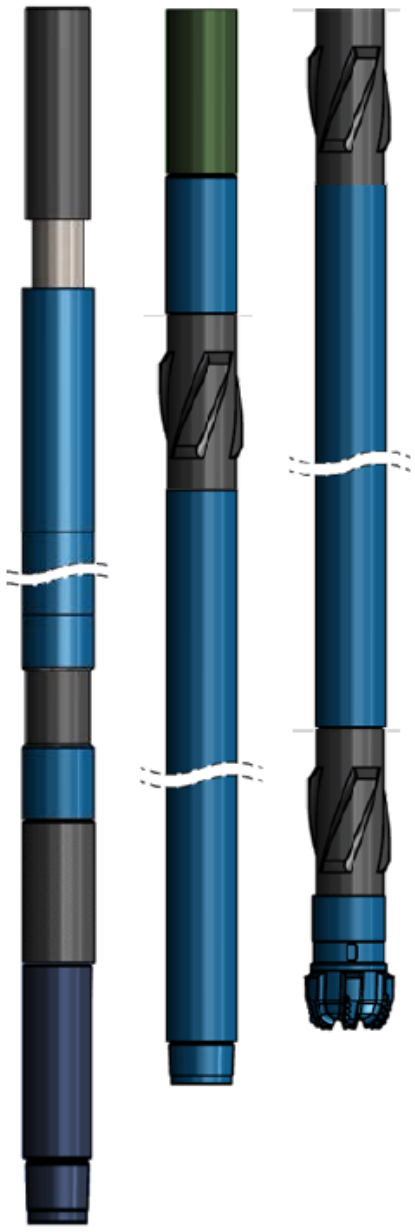
8.2. Core Run 2

The second core run was at 7,440' to 7,460'. The BHA used for this core run are shown in Figure 22 In response to the results of the first core run, several adjustments were made for

Run 2: The core barrel length was reduced to 20’, the full hole stabilizers were replaced with slick subs to reduce torque, and an 8-1/2” Wedgetail Roller Reamer was installed above the core barrel to dampen any string harmonics, and stick slip from above the BHA, in addition to removing any potential for whirl in the BHA.

Upon tripping in for the second core, there was ~3 ft of fill that was washed through and circulated clear before coring began. After reaching the bottom, the WOB was gradually increased to 12-14 klbs, and then maintained for the remainder of the run. The RPM, pump rate and surface pressure were very consistent through the run. At about 7,450’ the torque became erratic in comparison to the first half of the run. At 20’ the run was ended (full barrel) and tripped out of the hole. The average ROP over the run was 1.2 ft/hr.

On surface 12 ft. of core was recovered, with the Coring Technician noting the bottom about 5 ft. of the core was quite fractured including some sections resembling gravel. He also indicated the core catcher was not in its lowest position. The position of the catcher combined with the description of the core sample indicated that due to the nature of the core, the catcher was not able to function as intended. When the run ended and the coring BHA was hoisted, the core fell through the catcher and lower shoe until a section of core solid enough to engage the catcher was encountered.



Equipment Specifications

Core Barrel	
Barrel Dimensions (OD/ID/Length)	7.125" x 5.625" x 40'
Top Connection	4-1/2 IF
Top Sub ID	3.0"
Stabilizer Fishneck Length	11.5"
Stabilizer OD	8.375"
Make-Up Torque	30,000 ft-lbs
Yield Torque	70,000 ft-lbs
Overpull	860,000 lbs

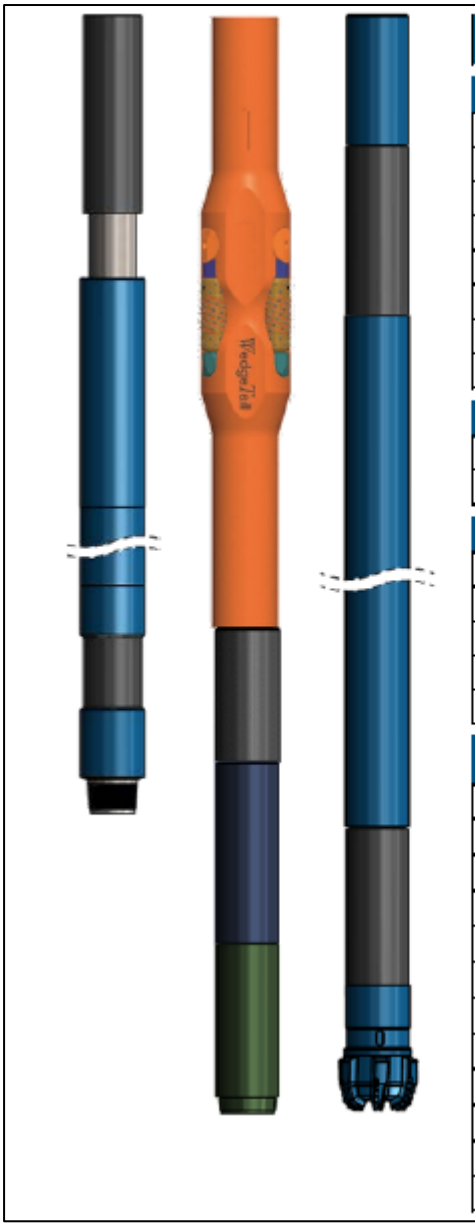
Inner Barrel	
Inner Barrel/Tube Type	Half Moon On-Ice
Dimensions (OD x ID)	4.40" x 4.125"

Core Head	
Type	MCI 905
OD x ID	8.5" x 4.0"
Core Size	4.0"
Blade Count	14
TFA (Inner Gauge)	1.7 in²

BHA Tally

ITEM No	DESCRIPTION	Length (ft)
1	Core Head	1.3
2	Stablizer	2.5
3	Outer Barrel	17.5
4	Stablizer	2.5
5	Outer Barrel	17.5
6	Gyro Stabilizer	2.5
7	Outer Barrel Head	2.0
8	Circulating Sub	2.7
9	Float Sub	2.7
10	Crossover (4-1/2 XH x 4-1/2 IF)	1.6
11	Coring Jar	17.4
	BHA Total Length (ft)	70.2

Figure 21: Coring BHA used for first core run at 6800'.



Equipment Specifications	
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Barrel Dimensions (OD/ID/Length)	7.125" x 5.625" x 20'
Top Connection	4-1/2 IF
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Stabilizer Fishneck Length	11.5"
Stabilizer OD	8.375"
Make-Up Torque	30,000 ft-lbs
Yield Torque	70,000 ft-lbs
Overpull	860,000 lbs
Inner Barrel	
Inner Barrel/Tube Type	Half Moon On-Ice
Dimensions (OD x ID)	4.40" x 4.125"
Core Head	
Type	MCI 905
OD x ID	8.5" x 4.0"
Core Size	4.0"
Blade Count	14
TFA	1.7 in²

BHA Tally		
ITEM No	DESCRIPTION	Length (ft)
1	Core Head	1.3
2	Slick Sub	2.5
3	Outer Barrel	17.5
4	Gyro Slick Sub	2.5
5	Outer Barrel Head	2
6	Circulating Sub	2.7
7	Float Sub	2.7
8	Crossover (4-1/2 IF x 4-1/2 XH)	1.6
9	Wedgetail Roller Reamer	5.9
10	Coring Jar	17.4
	BHA Total Length (ft)	56.1

Figure 22: BHA for core Run 2.

9. Testing

9.1 DFIT

A Diagnostic Fracture Injection Test (DFIT) was done after completion of the well, with several stages over 2 days, to stimulate the open hole section from 7,375 to 7,636 ft. (Figure 23). Prior to testing, a compression packer was set near the casing shoe, just inside the casing. A pressure and temperature tool carrier, built specifically for the project was deployed in the open hole section and provided reliable bottom hole pressure and temperature measurements during the DFIT. Tubing pressure and flow rate were recorded by the pumping services company, Resource Cementing, during injection. Analysis of this data in ongoing. Some aspects of this analysis include determination of the closure stress (analog to the minimum horizontal principal stress),

evaluation of the breakdown pressure and reopening pressures to infer the maximum horizontal principal stress, integration of the density logs to infer the vertical total stress and processing the post-closure shut-in data from the DFIT analyses to determine permeability.

Figure 23: Pump truck set up in foreground with rig over 58-32 during injection testing.

9.2 Pressure/Temperature surveys

The resource team monitored the daily mud temperatures during drilling as well as the and near-bottom temperatures recorded with maximum reading thermometers (MRT) during drilling. The MRT were run at the same time the single shot deviation surveys were conducted. To avoid damage to the tools and drill string, measurements were made as soon as possible after drilling stopped, typically less than an hour after mud circulation ceased. Mud temperatures in and out were recorded by the mud logger. A steady increase in heat extracted through the mud circulation demonstrated that the temperature in the hole was steadily increasing (despite the mud cooler reducing the mud temperature). The decision was made to cease drilling and mud circulation when the hole reached a depth of 6,800 ft. to confirm the thermal regime was close to the predicted conditions. A pressure temperature survey was run at roughly 6, 12, 18 and 24 hours after circulation stopped, with service provided by DiDrill Survey Services. Several methods were used to estimate the equilibrium temperature from the rate of thermal recovery. With the three heat up surveys, three different methods were used to

estimate the equilibrium temperature and suggested a temperature of 360-380°F (180-190°C) at 6,800 ft. A full heat up survey was completed on 2 November 2017, giving a maximum temperature of 385.9°F (196°C) at TD.

9.3 Acoustic Image logging

Schlumberger Formation MicroScanner Image (FMI) logging provided direct information on rock types, fracture abundances, fracture orientations and stress directions. The FMI tool was equipped with a four-arm caliper, which provides information on the well's ellipticity. Preliminary examination of the FMI logs indicates the upper 3,176 ft. of the well is composed of bedded alluvial deposits containing granitic clasts with a faulted transition from 3,176 ft. to 3,196 ft. The rocks below 3,196 ft. are granitic. Both drilling induced and natural fractures are present. FMI and Dipole Sonic Shear logs were included in the suite of the geophysical logs run in the open-hole between the 9-5/8 casing shoe and TD at 7536 ft. These logs were run again with the 7-inch casing cemented in the well to a depth of 7375 ft., after the injection stimulation of the lower part of the hole, to assess any changes that may have occurred during the stimulation.

10. **Appendices**