# SodM End of Well Report BRI-GT-01

Aardwarmte Vierpolders


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## GLOSSARY

| | |
|---|---|
| AH | Along hole |
| BGL | Below ground level |
| BHA | Bottom hole assembly |
| BOP | Blowout preventer |
| BPC | Balance Point Control |
| BRI-GT-01 | Brielle Geothermal 01 |
| BRI-GT-02 | Brielle Geothermal 02 |
| CBL | Cement bond log |
| CHH | Casing head housing |
| CP | Conductor Pipe |
| DP | Drill pipe |
| DSV | Drilling supervisor |
| EMW | Equivalent mud weight |
| ESP | Electric submersible pump |
| FIT | Formation integrity test |
| GL | Ground level |
| GOT | German Oil Tools |
| GR | Gamma-Ray |
| HSE | Health, Safety & Environment |
| HWDP | Heavyweight drillpipe |
| LCM | Lost circulation material |
| MD | Measured Depth |
| MWD | Measurement while drilling |
| NAP | Normaal Amsterdams Peil |
| NPT | Non-productive time |
| OH | Open hole |
| PBL | Circulation sub |
| PBR | Polished Bore Receptacle |
| PDC | Polycrystalline diamond compact |
| PDM | Positive displacement (mud) motor |
| PJSM | Pre-job safety meeting |
| POA | Plan of action |
| POOH | Pull out of hole |
| ppf | pounds per foot |
| PUW | Pick up weight |
| RIH | Run in hole |
| ROP | Rate of penetration |
| RSS | Rotary steerable system |
| RT | Rotary table |
| RTTS | Retrievable Test-Treat-Squeeze (packer) |
| s.g. | Specific gravity |
| SodM | Staatstoezicht op de Mijnen |
| SOW | Slack off weight |
| SPP | Stand pipe pressure |
| TD | Total depth |
| TOC | Top of cement |
| TOL | Top of liner |
| TP | Toolpusher |
| TVD | True vertical depth |
| USIT | Ultrasonic Imager Tool |
| WEP | Well Engineering Partners |
| WOB | Weight on bit |
| WOC | Wait on cement |
| WWS | Wire-wrapped screen |

# 1. General Project data

| | |
|---|---|
| **Field** | Brielle |
| **Well Number:** | BRI-GT-01 |
| **Well Name** | Geothermal Well BRI-GT-01 |
| **Well Type** | Geothermal Well Producer |
| **Start rig mobilisation** | 22-06-2015; 08:00 hr |
| **Spud date** | 03-07-2015; 17:00 hr |
| **End Date** | 17-08-2015; 13:00 hr |
| **Days Operational** | 44,8 |
| **Operator** | Aardwarmte Vierpolders |

| **Surface Location** | Latitude & Longitude | Geographical |
|---|---|---|
| | 51°52'21.656"N<br>4°09'33.818"E | X: 70,428<br>Y: 432,179 |

| | |
|---|---|
| **Grid Coordinate System** | Rijksdriehoeksmeting / Netherlands New |
| **Drilling Contractor** | KCA Deutag |
| **Drilling Rig** | T-49, Pyramid 270 mt |
| **Depth reference** | Rotary Table (RT), unless otherwise stated |

Project Management:

| | |
|---|---|
| **Project Manager** | Ad Raaijmakers (Hydreco) |
| **Drilling Advisor** | Henny Cornelissen |
| **Drilling Manager** | Maarten Middelburg |
| **Lead ops Engineer** | Kornelius Boersma |
| **HSE Manager** | Guus Wiering |

Drilling Supervisors on 2 week rotational scheme:

| | | |
|---|---|---|
| **Drilling Supervisor** | Karl Gollob | 29-06-2015 / 08-07-2015<br>18-07-2015 / 26-07-2015<br>08-08-2015 / 16-08-2015 |
| **Drilling Supervisor** | Peter Nutters | 08-07-2015 / 18-07-2015<br>26-07-2015 / 09-08-2015<br>16-08-2015 / 17-08-2015 |
| **Night Drilling Supervisor** | Bertjan Koers | 06-07-2015 / 19-07-2015<br>03-08-2015 / 14-08-2015 |
| **Night Drilling Supervisor** | Steven Hakkeling | 20-07-2015 / 02-08-2015<br>15-08-2015 / 17-08-2015 |

Sr. Geologist:

| | | |
|---|---|---|
| **Sr. Well Site Geologist** | Julien Smeulders | 03-07-2015 / 17-08-2015 |

## 2. Well summary

| | | | |
|---|---|---|---|
| **Primary Objective** | | Lower Buntsandstein | |
| **Primary Objective Depth** | | 2769 m MD | 2164 m TVD |
| **Total Depth** | | 3101 m MD | 2384 m TVD |
| **Elevation** | RT – GL | 6,93 m | |
| | GL – NAP | 0,80 m (NAP is 0,8m above ground level) | |
| | NAP – RT | 6,13 m | |

*Table 1: Well summary*

| Item | MD (m) | TVD (m) | Comments |
|---|---|---|---|
| Conductor | 227 | 227 | The 24" Conductor is installed in a pre-drilled hole and cemented in place with its shoe at 226 m MD RT. Moved the rig to location, rig up and commissioned same. |
| 17 ½" Hole TD | 1364 | 1239 | This section was drilled with a TCI (IADC 415) bit below a PDM directional BHA. Good performance was made until 731m when a topdrive failure caused 60.5 hrs delays. When the bit was back at bottom the MWD pulses couldn't be decoded and the MWD was changed out.<br>After drilling 297 meter the pressure started to fluctuate and the pop-off valve at the mud pump opened & pieces of rubber were observed at the shakers indicating a failure of the PDM. A round trip was made to replace the PDM. |
| 13 ⅜" Casing | 1360 | 1236 | 13 3/8" casing was run as per plan. From 1168 m to 1220 m the casing had to be washed down. In the Chalk formation the drag decreased again and the casing was run to setting depth without circulation. The casing was cemented to surface with 157.7 $m^3$ lead slurry of 1.57 s.g. and 15 $m^3$ tail slurry of 1.67 s.g. The casing was pressure tested on grey cement to 75 bar / 20 min. |
| 12 ¼" Hole TD | 2784 | 2175 | The 12 ¼" tanget section is drilled using the Autotrak RSS from Baker Hughes. Two bits were needed for drilling the section. First a TCI was used for drilling the Chert present in the Ommelanden formation. Below the Chert the bit was changed out for a PDC bit resulting in higher ROP's. Some tight spots and overpulls were observed on the trip out. |
| 9 ⅝" Liner | 2779 | 2172 | The 9 5/8" liner was successfully run to setting depth. Setting the liner hanger went as per plan. The liner was cemented with 62 $m^3$ cement of 1.70 s.g (single slurry). A pressure test to 115 bar at the bump was successful. Excess cement was circulated out to surface. |
| 8 ½" Hole TD | 3101 | 2384 | After drilling out the shoetrack the well was displaced to drill-in fluid. A LOT below the 9 5/8" shoe was done to 1,52 s.g. TD was reached circa 12 meters in the Rogenstein formation. Good performance was made with the Autotrak RSS in combination with a Mirco-core bit from Tercel. Unfortunately no micro-cores were observed at surface. |
| 6 ⅝"Liner | 3071 | 2364 | 6 5/8" x 7" OD wire wrapped screens (250 micron) were run to setting depth at 3098 m. The hole was in good condition. Setting liner hanger & packer failed and the liner was accidently pulled up 27 m, most likely due to high friction between the setting tool and the (short) 6 5/8" liner. A tieback packer was run and successfully set on top of the liner hanger. |

## 2.1 Directional plots

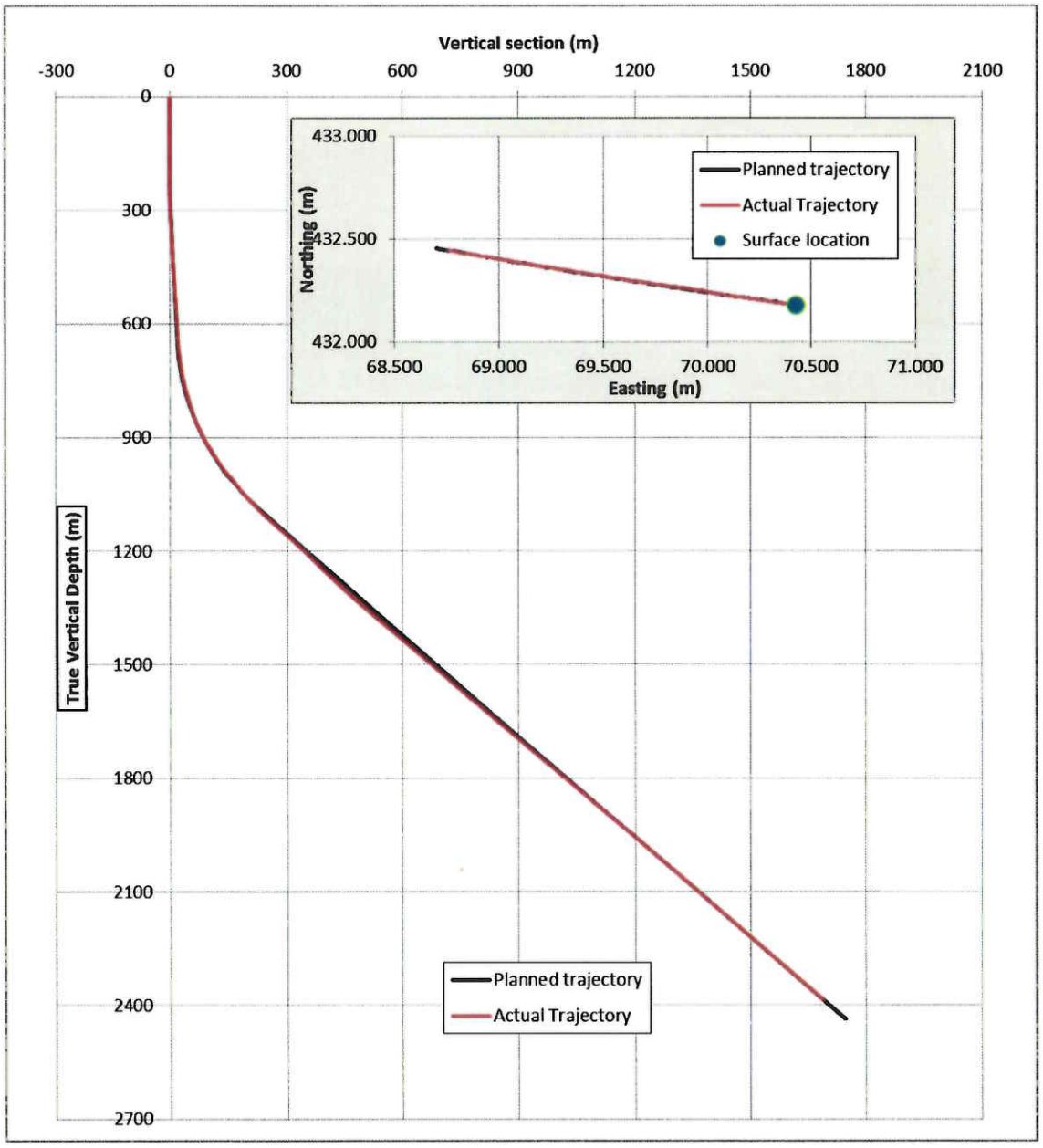



*Figure 1: BRI-GT-01 Vertical Section plot and plan view plot- drilled vs. planned*

## 2.2 Technical summary

### 2.2.1 Casing

*Table 2: BRI-GT-01 tubular summary*

| Item | Top m MD | Bottom m MD | Weight | Grade | Connection |
|---|---|---|---|---|---|
| 24" Conductor | 0 | 226 | 125,7 ppf | X65 | welded |
| 13 ⅜" Casing | 0 | 1360 | 68 ppf | L80 | VAM TOP |
| 9 ⅝" Liner | 1252 | 2779 | 47 ppf | L80 | Polseal |
| 6 ⅝" Liner | 2682 | 3071 | 24 ppf 7" WWS* | L80 | VAGT |

*Screen interval from 2743 m – 3057 m

### 2.2.2 Cement

*Table 3: BRI-GT-01 cement summary*

| Item | TOC (MD) | Lead Slurry Volume ($m^3$) | Lead Slurry Weight (s.g.) | Tail Slurry Volume ($m^3$) | Tail Slurry Weight (s.g.) | Type |
|---|---|---|---|---|---|---|
| 13 ⅜" Casing | surface | 157,7 | 1,57 | 15 | 1,67 | PozzoCemoil |
| 9 ⅝" Liner | 1252* | 61.9 | 1.70 | n/a | n/a | PozzoCemoil |

*Based on CBL log

# 3. Drilling fluid summary

Per section the following drilling fluid types have been used:

*Table 4: BRI-GT-01 drilling fluid summary*

| Section | Type | Density Min – Max |
|---|---|---|
| 17-1/2" | KCl-Glycol Polymer (AMC Glycodrill) | 1,06 – 1,17 |
| 12 ¼" | KCl-Glycol Polymer (AMC Glycodrill) | 1,12 – 1,18 |
| 8 ½" | Drill-in Fluid | 1,13 – 1,15 |

The figure below shows the mud weight versus depth during drilling operations.

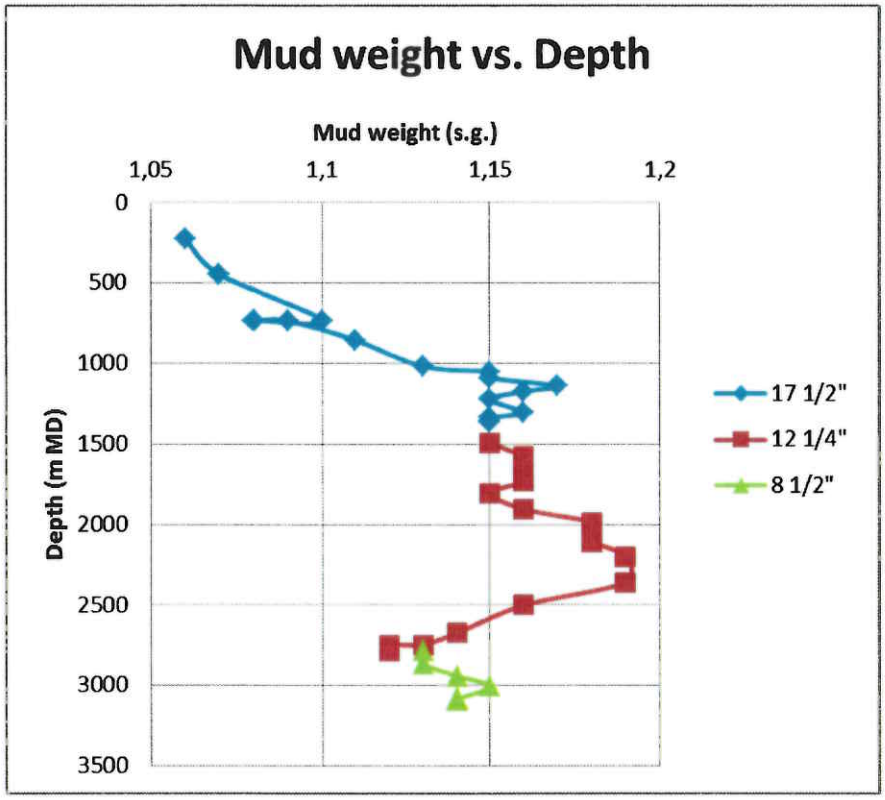



*Figure 2: BRI-GT-01 mud weight vs. depth*

# 4. Geology

Below the geological column with vertical and along hole depths below RT. Table 5 shows the lithology to the Texel formation, Table 6 to TD.

*Table 5: BRI-GT-01 geological summary part 1/2*

| TD @ 03-08-2015 | Lithostratigraphic Column Brielle | | | BRI-GT-01 | |
|---|---|---|---|---|---|
| **Group** | **Formation** | **Member** | **Lithology** | *TV-RT Depth(m)* | *AH-RT Depth (m)* |
| **Upper North Sea** NU | "Diverse" | | Diverse continental deposits, mostly fluvial sands and silts intercalated by layers of grey or greenish-grey, silty clays. | 6 | **6** |
| | **Maassluis** NUMS | | Fine to medium coarse sand, calcareous, micaceous and with marine shells. Small intercalations of silty clays, grey to dark grey. Locally some wood, reed and roots are | 75 | **75** |
| | **Oosterhout** NUOO | | Succession of sands, sandy clays, and grey and greenish clays. The glauconite content is moderate to low. Locally rich in shells and bryozoans. | 225 | **225** |
| | **Breda** NUBR | | Sequence of marine, glauconitic sands, sandy clays and clays. A glauconite-rich layer occurs at the base. | 347 | **347** |
| **Middle North Sea** NM | **Rupel** NMRU | **Rupel Clay** NMRFC | Clays that become more silty towards basis and top. It is rich in pyrite, contains hardly any glauconite and calcium carbonate tends to be concentrated in the septaria layers. | 360 | **360** |
| | | **Vessem** NMRFV | Silty to clayey sands with a low glauconite content; flint pebbles or phosphorite nodules commonly occur at the base. | 458 | **458** |
| **Lower North Sea** NL | **Dongen** NLDO | **Asse** NLFFB | Dark greenish-grey and blue-grey, plastic clays. The unit locally shows indications of bioturbation, and may be glauconitic and somewhat micaceous. | 591 | **592** |
| | | **Brussel Sand** NLFFS | Green-grey, glauconitic, very fine-grained sand with a number of hard, calcareous sandstone layers of some dm thickness . Towards the base of the unit the clay content increases, and the amount of glauconite decreases. | 641 | **642** |
| | | **Ieper** NLFFI | A soft, tough and sticky to hardened and friable clay. The lower part has a brown-grey colour, contains pyrite, coalified plant remains and is non-calcareous. The upper 2/3 has a green-grey colour with a nr of sandstone beds. | 748 | **750** |
| | | **Basal Dongen Sand** NLLFD | Light green-grey, locally glauconitic, usually thin sand with a fining-upward character. It can be very argillaceous, and may locally contain some well- | 1078 | **1134** |
| | **Landen** NLLA | **Landen Clay** NLLFC | Dark-green, hard, flaky clay, somewhat silty, containing glauconite, pyrite and mica. The basal part of the member can be marly and of a lighter colour. | 1083 | **1142** |
| **Chalk** CK | **Houthem** CKHM | | Soft, light grey to light yellow chalky limestones. It can contain calcareous concretions, fossils and hardgrounds with shell fragments. Its base is glauconitic. | 1156 | **1245** |
| | **Ommelanden** CKGR | | Succession of white, yellowish-white or light-grey, fine grained limestones, in places argillaceous. Layers of chert are common. Along the basin edge coarse, bioclastic limestones and tongues of sandstone occur. | 1240 | **1366** |
| | **Texel** CKTX | **Texel Greensand** CKTXG | Greenish, glauconitic, calcareous sandstones with intercalated marls. | 1870 | **2320** |

*Table 6: BRI-GT-01 geological summary part 2/2*

| | | | | | |
|---|---|---|---|---|---|
| **Rijnland** KN | **Holland** KNGL | **Spijkenisse Greensand** KNGLS | Mainly coarse-grained, greenish grey, glauconitic sandstones, locally with argillaceous matrix or calcareous cementation. | 1878 | **2332** |
| | | **Lower Holland Marl** KNGLL | It is developed as fossiliferous, glauconitic and intensely bioturbated, greenish grey, silty to very silty or sandy, glauconitic marls and claystones. | 1935,5 | **2420** |
| | **Vlieland Sandstone** KNNS | **De Lier Sandstone** KNNSL | Alternation of thin-bedded, very fine- to fine-grained argillaceous sandstones, generally glauconitic and lignitic. Also sandy claystones, glauconitic with shell | 1952,5 | **2446** |
| | | **IJsselmonde Sandstone** KNNSY | Massive sandstone, very fine- to medium-grained, lignitic, locally glauconitic and/or with sideritic concretions. Calcareous cemented beds are common; locally shells and shell fragments are present. | 2008 | **2532** |
| **Upper Germanic** | **Keuper** RNKP | **Upper Keuper Claystone** RNKP | Predominantly grey, silty claystones and marls with streaks of fine-grained sandstone. | 2062 | **2616** |
| | | **Dolomitic Keuper** RNKPD | A sequence of anhydritic, dolomitic or marly claystones, containing fine-grained sandstone intercalations. Grey to green colours are common, but red claystones also occur. | 2068 | **2625** |
| | | **Red Keuper Claystone** RNKPR | Red, silty claystones or marlstones, which yield typical high gamma-ray readings. These rocks are strongly variegated displaying red, green, yellow and grey colours. | 2084 | **2649** |
| | **Muschelkalk** RNMU | **Middle Muschelkalk Marl** RNMUA | Light greenish/grey marlstone unit which contains some anhydrite beds in the basal part. | 2085,5 | **2652,5** |
| | | **Muschelkalk Evaporite** RNMUE | The unit consists of a thin succession of anhydrites. | 2088,5 | **2657** |
| | | **Lower Muschelkalk** RNMUL | Alternation of mainly light-greenish/grey limestone or dolomite and marl beds. | 2090 | **2659** |
| | **Röt** RNRO | **Upper Röt Fringe Claystone** RNROY | A red-brown, silty, sandy or anhydritic claystone. It may also contain some dolomitic stringers. | 2111,5 | **2693** |
| | | **Röt Fringe Sandstone** RNROF | Grey, cross-bedded, arkosic sandstones with intercalated claystone beds. | 2121 | **2708** |
| | | **Lower Röt Fringe Claystone** RNROL | Red-brown silty claystone, often with an anhydrite or anhydrite-cemented sandstone bed at its base. | 2128,5 | **2719** |
| | **Solling** RNSO | **Solling Claystone** RNSOC | Red, green and locally grey claystones, which often show high gamma-ray readings in the basal part and some sand stringers. | 2135 | **2730** |
| | | **Basal Solling Sandstone** RNSOB | Light-coloured, massive or cross-bedded, and dolomite-cemented sandstone. | 2136,5 | **2732** |
| **Lower Germanic Trias** RB | **Hardegsen** RBMH | | Several stacked alternations of off-white to pink sandstones and some red claystones. | 2164 | **2767** |
| | **Detfurth** RBMD | **Lower Detfurth Sandstone** RBMDL | A massive, light-coloured, arkosic (feldspar) sandstone. | 2231 | **2869** |
| | **Volpriehausen** RBMV | **Upper Volpriehausen Sandstone** RBMVU | Light-brown sandstone, usually carbonate-cemented. The thin claystone beds have a greenish colour and show a rhythmic alternation of thin sandstone and claystone laminae. | 2241 | **2884** |
| | | **Lower Volpriehausen Sandstone** RBMVL | Pink to grey, (sub-)arkosic sandstone unit. The member contains reworked material of the underlying formation in its lower part, which in general is strongly cemented. | 2336 | **3028,5** |
| | **Lower Buntsandstein** RBSH | **Rogenstein** RBSHR | A cyclical alternation of red-brown and green, in places grey, occasionally anhydritic claystones, siltstones and sandstones or calcareous oolite beds. | 2375 | **3088,5** |
| | | | *TD* | 2384 | **3101** |

# 5. Well schematic

A detailed well schematic summarizing all casing sizes is shown below.

Note: well depth is not to scale.

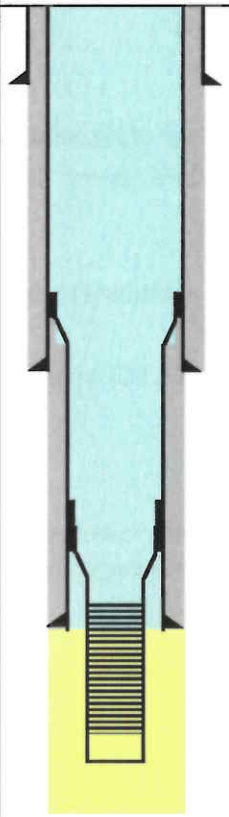
| BRI-GT-01 Geothermal<br>depths from RT (6.7m above GL) | Wellhead and Xmastree 13 5/8" 5K Uztell (slip-on) | Depth m tvd | Depth m ah | Hole ID in | Pipe OD in | Collar OD in (nom) | Pipe ID in | Pipe ID in (drift) |
|---|---|---|---|---|---|---|---|---|
| 24" welded conductor |  | 226 | 226 | | 24,000 | welded | 23,000 | |
| Liner hanger 13 3/8" x 9 5/8" (TOL) | | 1161 | 1252 | | | | | |
| 13 3/8" 68 ppf L80 VAMTOP | | 1236 | 1360 | 17,5 | 13,375 | 14,175 | 12,415 | 12,259 |
| Tieback packer with PBR | | 2109 | 2682 | (top PBR) | Length PBR = 2,975 ID=190,5mm | | | |
| Liner hanger 9 5/8" x 6 5/8" (TOL) | | 2112 | 2687 | | | | | |
| Top 6 5/8" x 7" WWS | | 2148 | 2743 | | | | | |
| 9 5/8" 47 ppf L80 liner Polseal | | 2172 | 2779 | 12 1/4 | 9,625 | 10,650 | 8,681 | 8,525 |
| Top reservoir | | 2172 | 2779 | | | | | |
| Bottom 6 5/8" x 7" WWS | | 2355 | 3057 | | | | | |
| 6 5/8" WWS liner 24 ppf L80 VAGT | | 2364 | 3071 | | | | | |
| Bottom reservoir (top Rogenstein) | | 2376 | 3089 | | | | | |
| TD | | 2384 | 3101 | 8 1/2 | TD | | | |
| | | | | | | | | *Drawing is not to scale* |

*Figure 3: BRI-GT-01 well schematic*

# 6. HSE performance

## 6.1 General

To ensure that the operation is carried out in a safe manner, several HSE tools have been implemented both by Aardwarmte Vierpolders and KCA Deutag during the drilling of BRI-GT-01.

KCA Deutag's Permit to Work system was a tool used in order to perform additional activities outside regular drilling activities that carry a potential risk. Both the Toolpusher's and DSV's approval were required for a Permit to Work to come into effect.

Other HSE tools utilized on location were:

- Toolbox meeting during every shift change of rig contractor (05:30 & 17:30)
- Pre-job safety meetings (PJSM) before every non-drilling operation (casing running, cementing, well-test etc.)
- General safety meetings with rig crews
- Local Fire brigade location visit and acquaintance to operations
- Stop card system of KCA Deutag
- Regular HSE inspections carried out by GDL HSE coordinator
- Weekly HSE meeting

## 6.2 Incidents

During the clean-out phase of the welltest an electrical connection caught fire in the VSD container of Centrilift. The fire was controlled with a CO2 fire extinguisher. The incident did not lead to injuries or major damage to equipment.

## 6.3 Drills / Emergency exercises, inspections & audits

Drill / emergency exercises:

- Fire drills (04/07/2015,25/07/2015, 09/08/2015, 17/08/2015)
- Muster drills (11/07/2015, 25/07/2015, 09/08/2015, 17/08/2015)
- Kick drills (21/07/2015, 01/08/2015, 08/08/2015)
- BOP tests (18/07/2015, 01/08/2015)