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HON-GT-01 ST1 & 02

Project 1156

Alternatives for the Honselersdijk Doublet

- Because of presence of an obstruction in HON-GT-01 ST1 at a depth of 2422m AH (-2249 m TVD, see next slide). PanTerra was asked if a sandstone different from the Delft and Alblasserdam could be a geothermal producer

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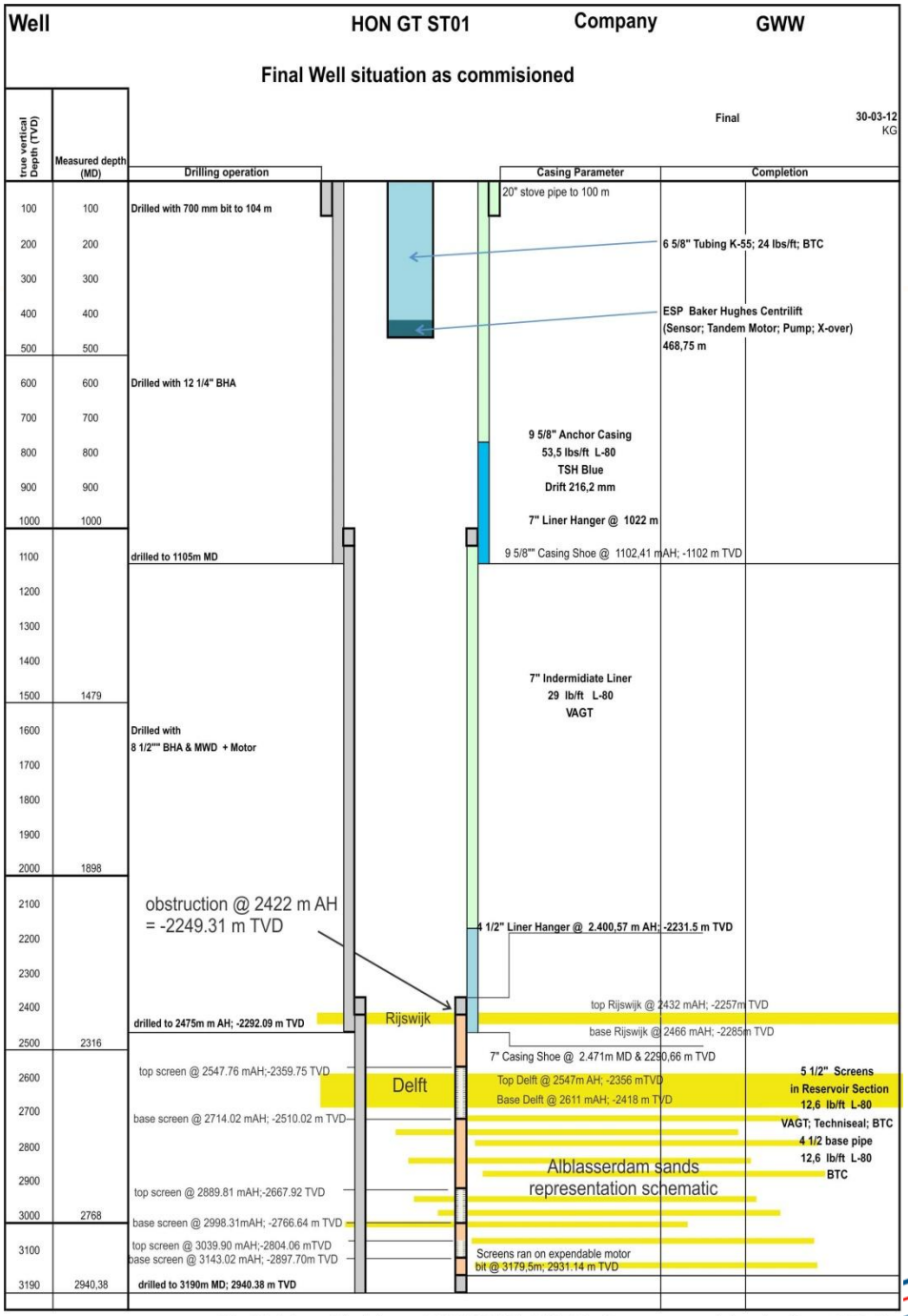

Modified from: *Final Layout HON-GT-01-01ST Producer as commisioned.pdf* 1156-03

Completion diagram

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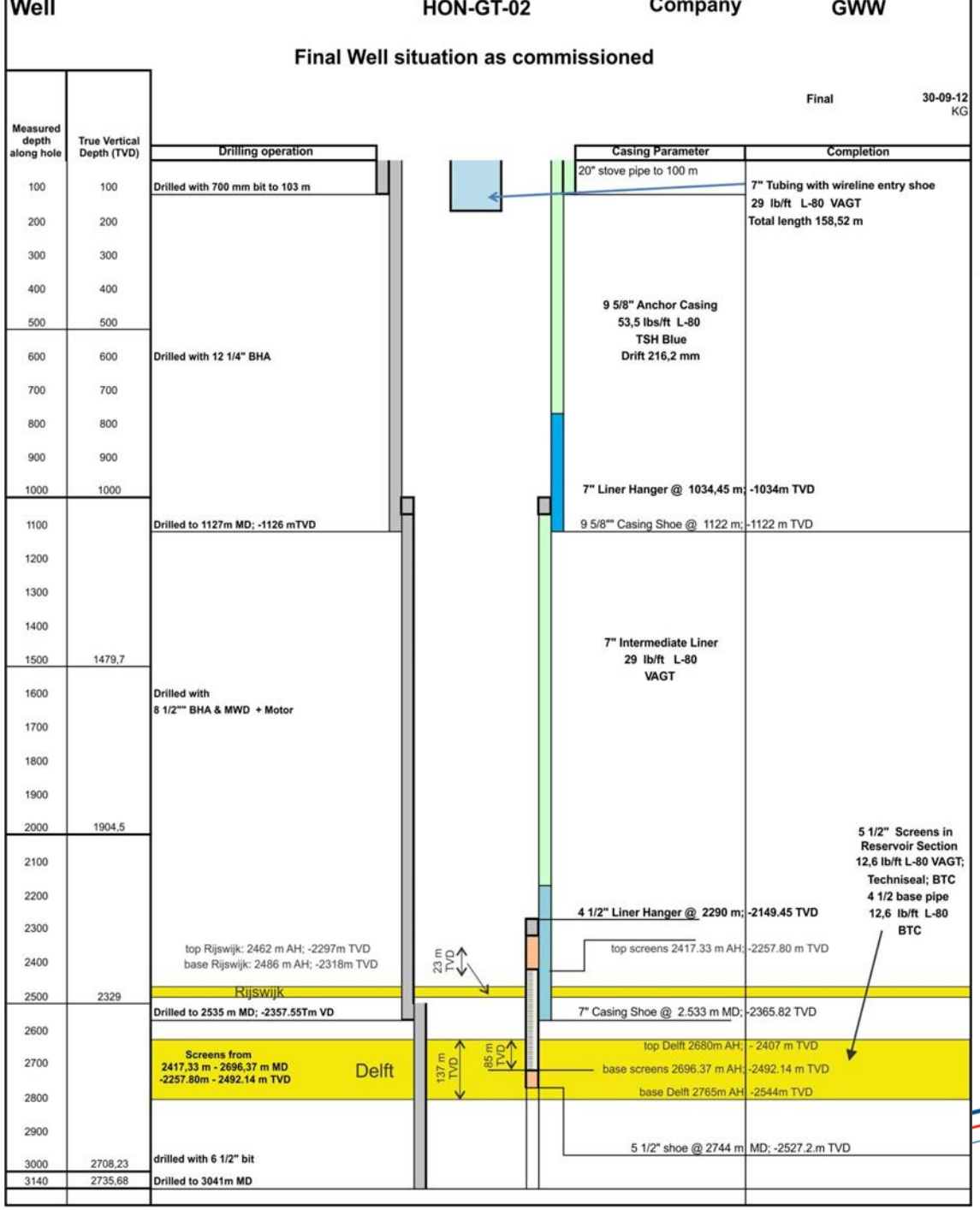

Modified from original pdf: *Final Layout HON-GT-02 Injector .pdf* 1156-02

Completion diagram

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Rijswijk Scenario

Rijswijk Sandstone

Both wells have a Rijswijk sandstone. This sandstone is 23 m in HON-GT-01 ST1 and 21 m in HON-GT-02. However, the Rijswijk section is in both wells behind the 7” casing and behind de 4.5”liner .

We have calculated a potential capacity of this sandstone using DoubletCalc and assuming the best possible completion. This Doublet Calc calculation is based on a completion with the 7 “ casing set just above the top of the reservoir and a completion with normal screens over the reservoir section. To achieve this, 1) the liner should be removed and 2) the 7” casing over the reservoir should be removed as well and replaced by a completion. Apart from whether this is technically possible, it allows us to estimate the best possible production from the Rijswijk Sandstone alone.

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Assuming a permeability of the Rijswijk between 100 and 300 mD, production could be:

- 1.3 Mw (P90) - 2 MW (P50) - 2.6 Mw (P10).

Assuming a permeability of the Rijswijk between 100 and 500 mD, production could be:

- 1.8 Mw (P90) – 3.1 MW (P50) – 4.2 Mw (P10).

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Rijswijk Scenario DoubletCalc

Doublet Calculator 1.4

number of simulation runs (-) 1000 | Calculate ! | Open Scenario | Save Scenario | Exit Program

file: ... westland production problem investigation\2. data\doubletcalc scenario rijswijk single.xml

Geotechnical input

A) Aquifer properties

Property	min	median	max
aquifer permeability (mD)	100	200	300
aquifer net to gross (-)	0.85	0.9	0.95
aquifer gross thickness (m)	21	22	23
aquifer top at producer (m TVD)	2031.0	2257	2483.0
aquifer top at injector (m TVD)	2067.0	2297	2527.0
aquifer water salinity (ppm)	108000	120000	132000

Property	value
aquifer kh/kv ratio (-)	1
surface temperature (°C)	10.0
geothermal gradient (°C/m)	0.033
[mid aquifer temperature producer (°C)]	0.0
[aquifer pressure at producer (bar)]	0.0
[aquifer pressure at injector (bar)]	0.0

B) Doublet and pump properties

Property	value
exit temperature heat exchanger (°C)	35
distance wells at aquifer level (m)	1400
pump system efficiency (-)	0.7
production pump depth (m)	500
pump pressure difference (bar)	60

C) Well properties

segment length (m) 50

Producer	
outer diameter producer (inch)	8.5
skin producer (-)	0
penetration angle producer (deg)	32
skin due to penetration angle p (-)	-0.13

Segment	tubing segment sections p (m AH)	tubing segment depth p (m TVD)	tubing inner diameter p (inch)	tubing roughness p (milli-inch)
1	500	500	6.625	1.8
2	1105	1105	9.625	1.8
3	2432	2257	7	1.8
4				
5				
6				
7				

Injector	
outer diameter injector (inch)	8.5
skin injector (-)	0
penetration angle injector (deg)	32
skin due to penetration angle i (-)	-0.13

Segment	tubing segment sections i (m AH)	tubing segment depth i (m TVD)	tubing inner diameter i (inch)	tubing roughness i (milli-inch)
1	1105	1105	9.625	1.8
2	2462	2297	7	1.8
3				
4				
5				
6				
7				

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Faults in the section

The Rijswijk is a relatively thin sandstone, this means that even relatively small faults could interfere with the communication between the producer and the injector.

Close inspection of the up-hole logs of the injector and the producer revealed about 25 m missing section @-1985 m TVD in HON-GT-01 when compared with HON-GT-02, showing presence of a normal fault dissecting HON-GT-01

Depending on strike and dip of this fault it could be present between the injector and the producer. A figure is in the next slide that illustrates the possibilities. There is at present no way of knowing this, the chance that the faults is between injector and producer is thus 50%. In addition to the strike & dip, the length of the fault is of importance. The seismic data in the area is of insufficient quality to identify the fault.

A fault of this magnitude would have limited effect on the communication in the Delft Sandstone, just because of the much larger thickness of the Delft.

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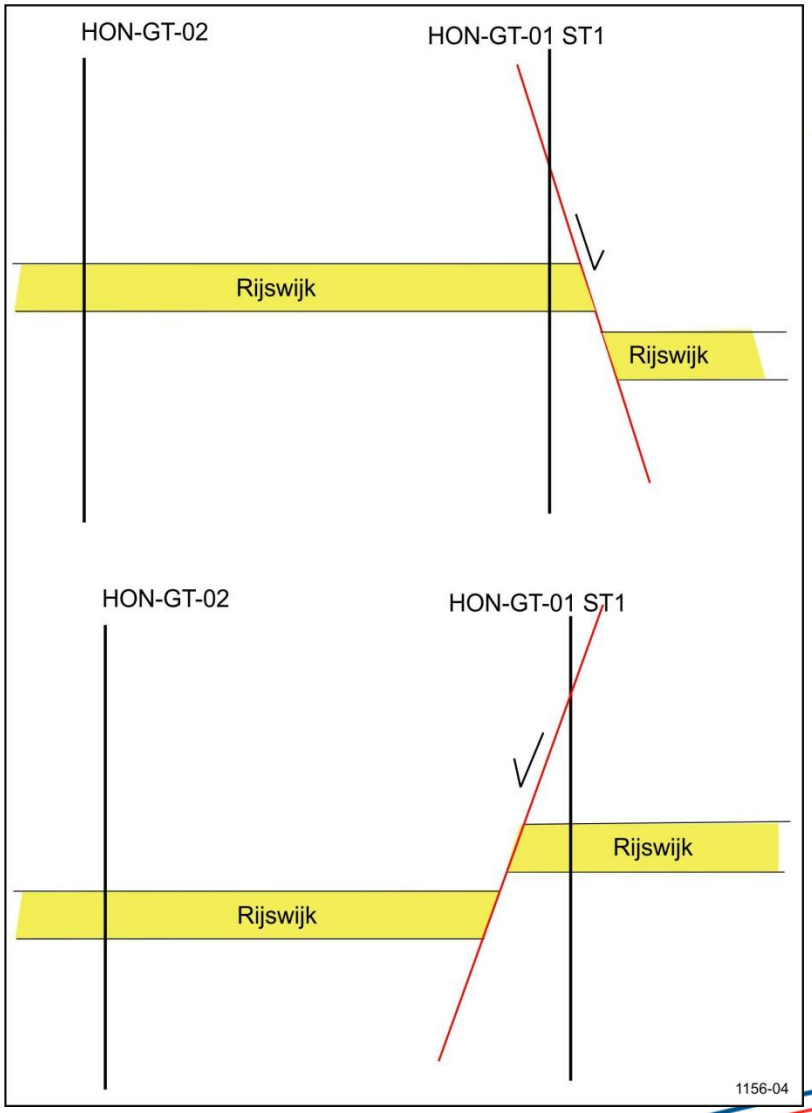
The Two Fault Possibilities



Berkel Scenario

Berkel Sandstone.

The Berkel & Berkel Sand-Shale Members have poorly developed sandstones in the area of HON-GT-01 ST1 and HON-GT-02. Log patterns allow detailed correlation of the section in the wells. The section shows sandy intervals but sands are shaley. Clean sands are not developed. There is no data available on the reservoir characteristics of such shaley sands but it is most likely that these sands have limited permeability, possibly similar to the permeability of the Holland Green Sand or the De Lier Member which are both in the range of 20-80 mD.

With the following assumptions: 1) an ideal completion set-up, 2) thickness shaley sands of 50m, 3) depth 2100m, 4) N/G approx 0.9; 5) permeability shaley sands 50-100 mD; 7) pump pressure difference 60 bar,

Such a shaley sandstone would have a capacity in the order of :

- 1.1 MW(P10)-1.42 MW (P50)-1.76(P90) MW.

However, the shaley sands are currently behind casing and whether an “ideal completion” can be achieved at reasonable cost is not investigated.

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Comments on the completion (in Dutch)

- Met betrekking tot de mogelijke oorzaak: onze associate productie geoloog merkte op dat Wire-Wrapped Screens (WWS) redelijk kwetsbaar zijn. Hij sluit niet uit dat met de hoge water flow rates erosie kan optreden door zandkorreltjes, met name als de WWS al een kleine beschadiging had door transport of tijdens run-in hole. Dat betekent dat de put langzaam wat zand is gaan produceren, wat in de filters zou moeten zijn teruggevonden. Bovendien raakt een ESP snel stuk door zandproductie. Misschien is het goed om er verifiëren of er achteraf indicaties waren van zandproductie in de dagen/weken voorafgaande aan de blokkade.

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Comments on the completion (in Dutch)

- Het perforeren en produceren van de Rijswijk lijkt niet technisch geen goede optie. In de productieput bevindt de Rijswijk zich ter hoogte van de overlap tussen de 7” en 4.5” liner. Er moet dus door twee verbuizingen heen geperforeerd worden, wat mogelijk is maar niet optimaal. Daarnaast is het nodig een scherm of gravelpack te plaatsen om zand uit te sluiten, en dit gaat niet in een 4.5” liner. Dus de 4.5” liner moet worden verwijderd over de Rijswijk zand sectie, waarvoor een boorinstallatie nodig is. En in dat geval is een sidetrack over de Delft zandsteen waarschijnlijk zo wie zo een beter optie.

Comments on the completion (in Dutch)

- Zou je na het verwijderen van de 4.5” liner toch gaan voor een perforatie van de 7” casing, dan raadt onze associate productietechnoloog een WWS af: waarschijnlijk erodeert zo’n WWS snel omdat het bloot staat aan hoge productie uit de geschoten gaten. Een internal gravel pack leidt uit zijn ervaring tot 30%, en over de tijd tot wel 80% verlies aan productie door langzame verstopping. De beste zand exclusie methode is volgens hem een WWS met frac en pack, zoals Shell ook toepast in de Gulf of Mexico. Dit levert weinig skin op. Maar is ook duurder.

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The end of the presentation