Smarte brønnløsninger for utvinning av Heidrunfeltets dype formasjoner

Elling Sletfjerding, Andre Strupstad, Cyril Nardi, Lars Inge Berge
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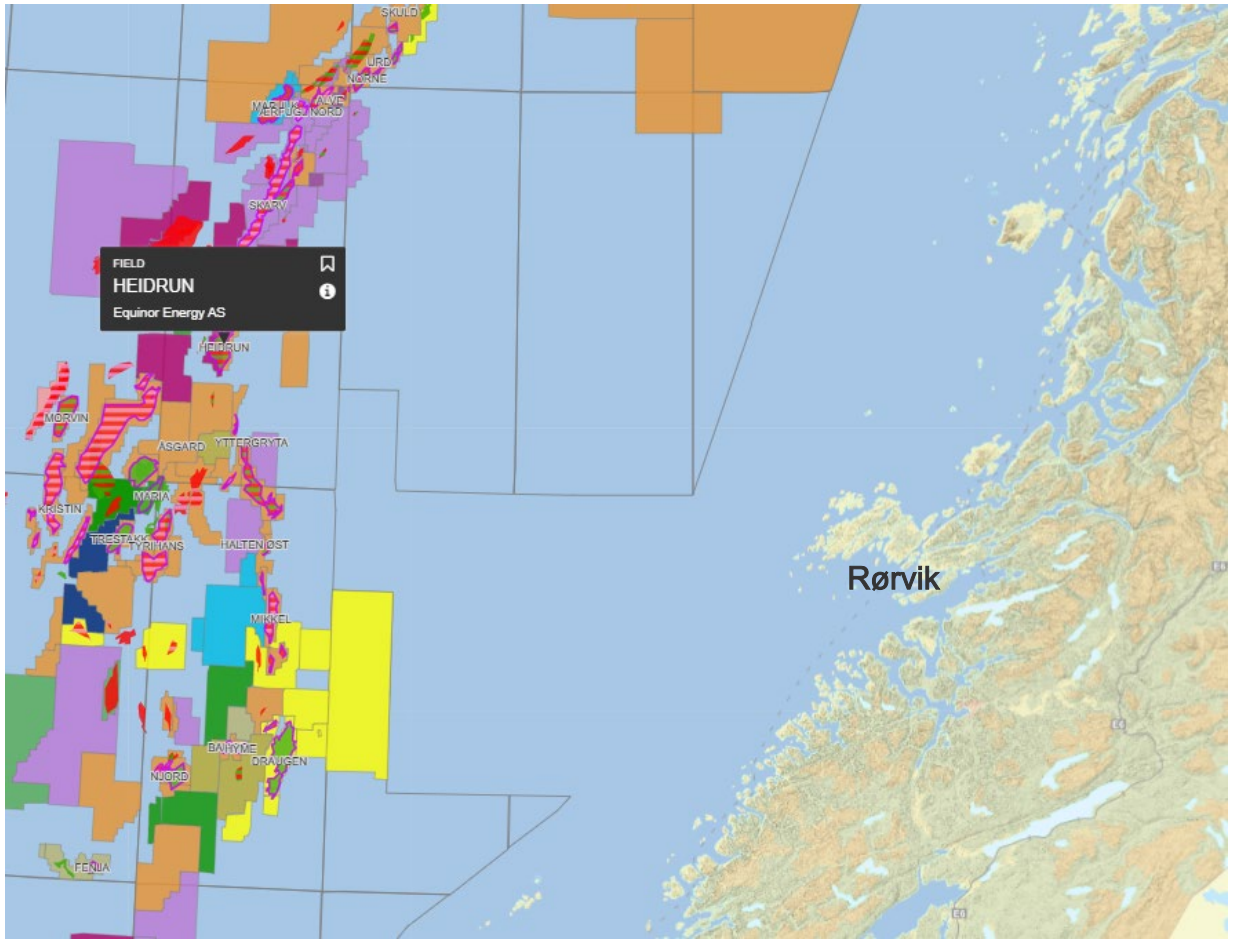
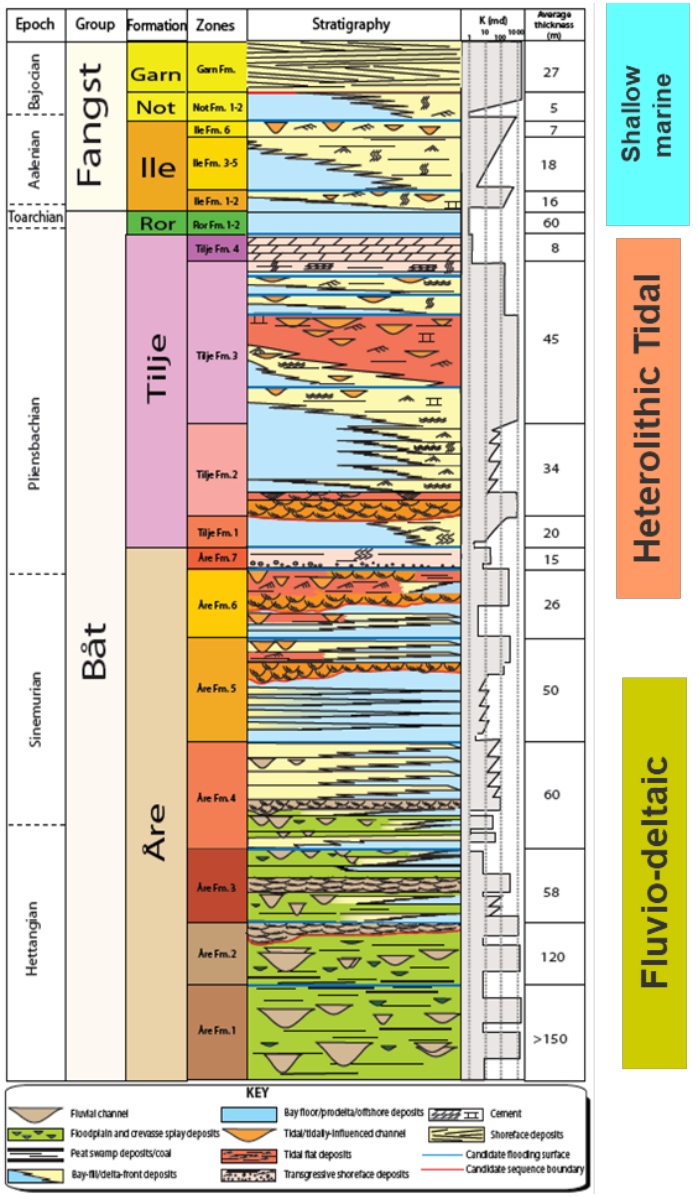
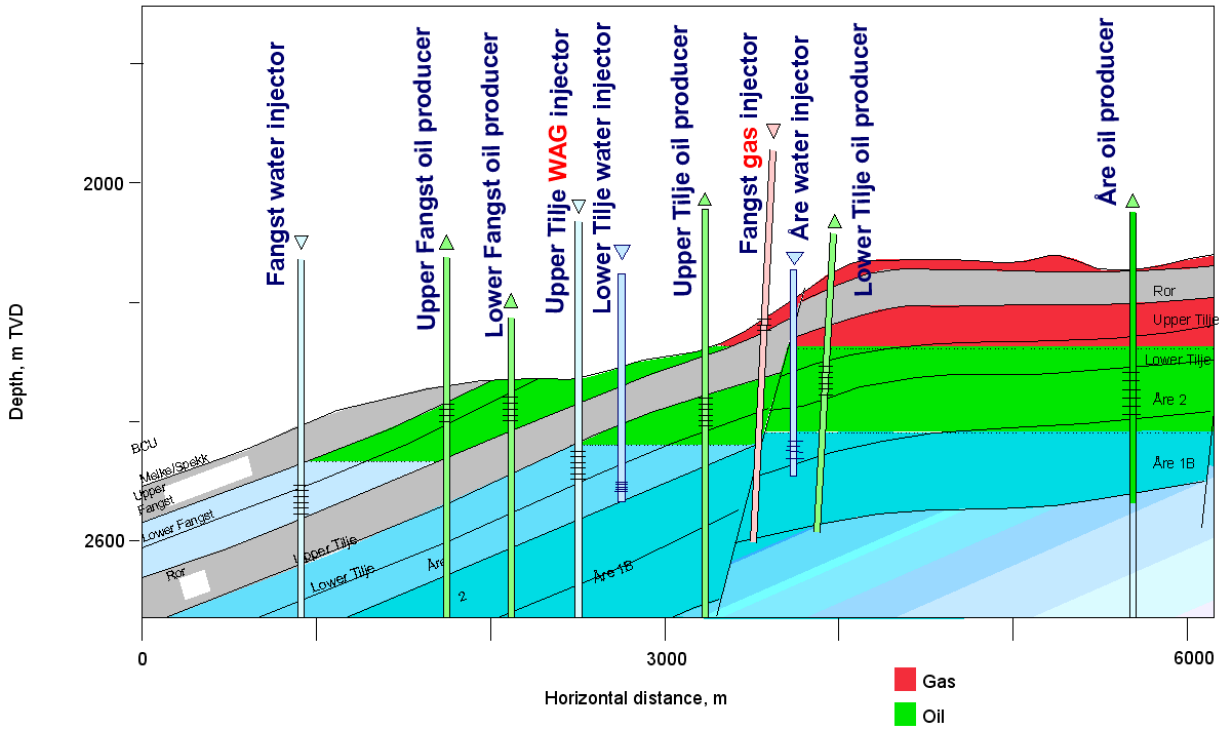
Heidrun Field

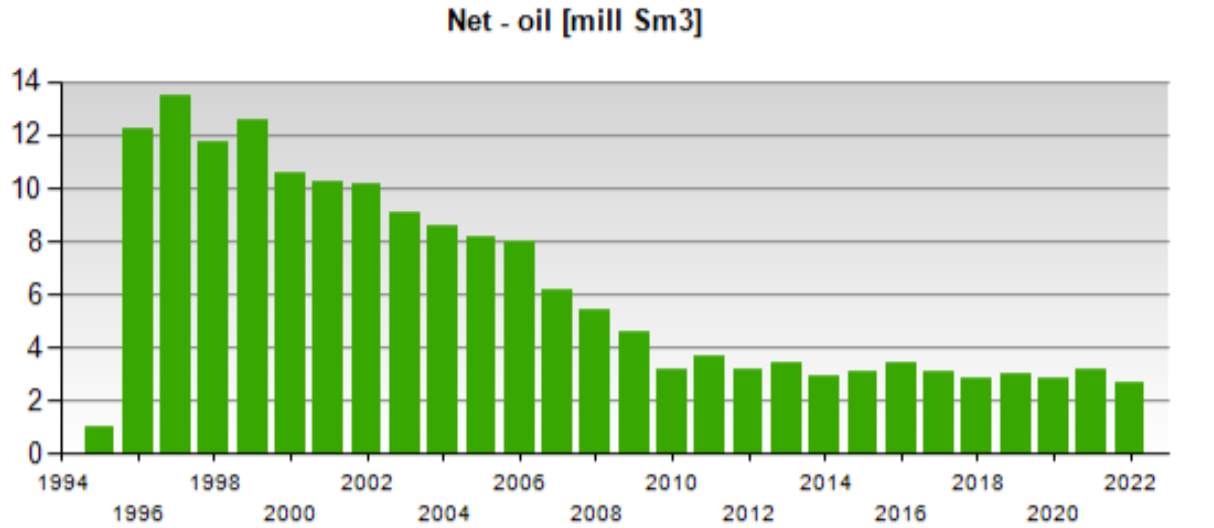


Heidrun field installations and geology

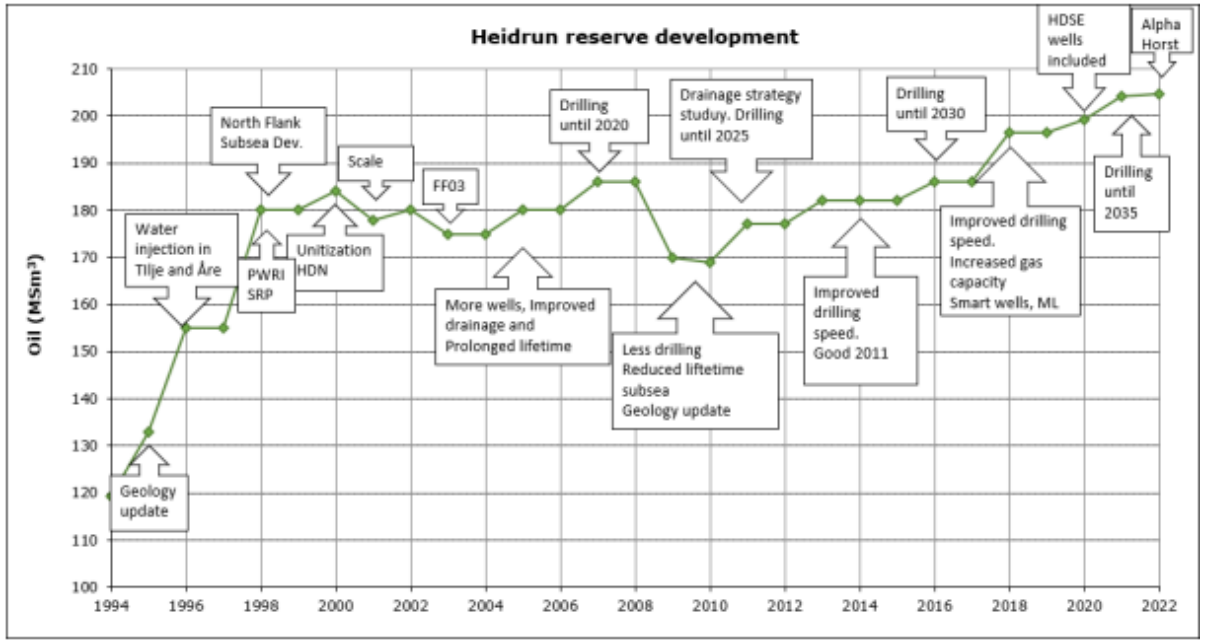


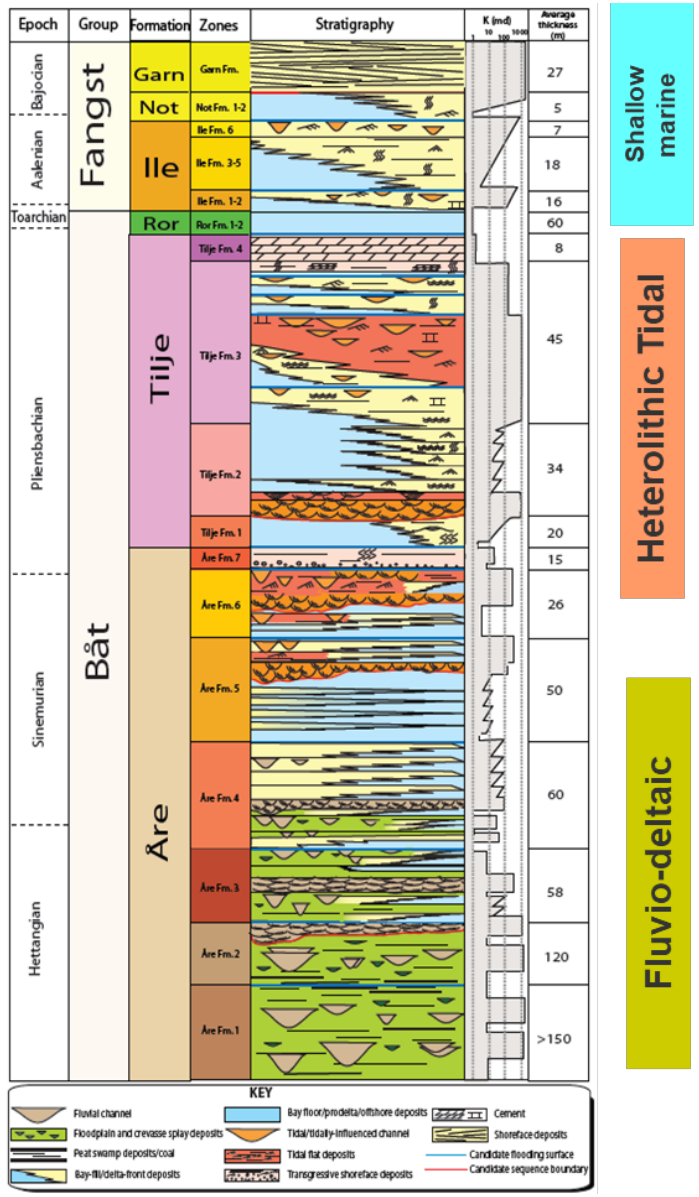
Heidrun field drainage strategy





Heidrun IOR and well solutions





Shallow marine

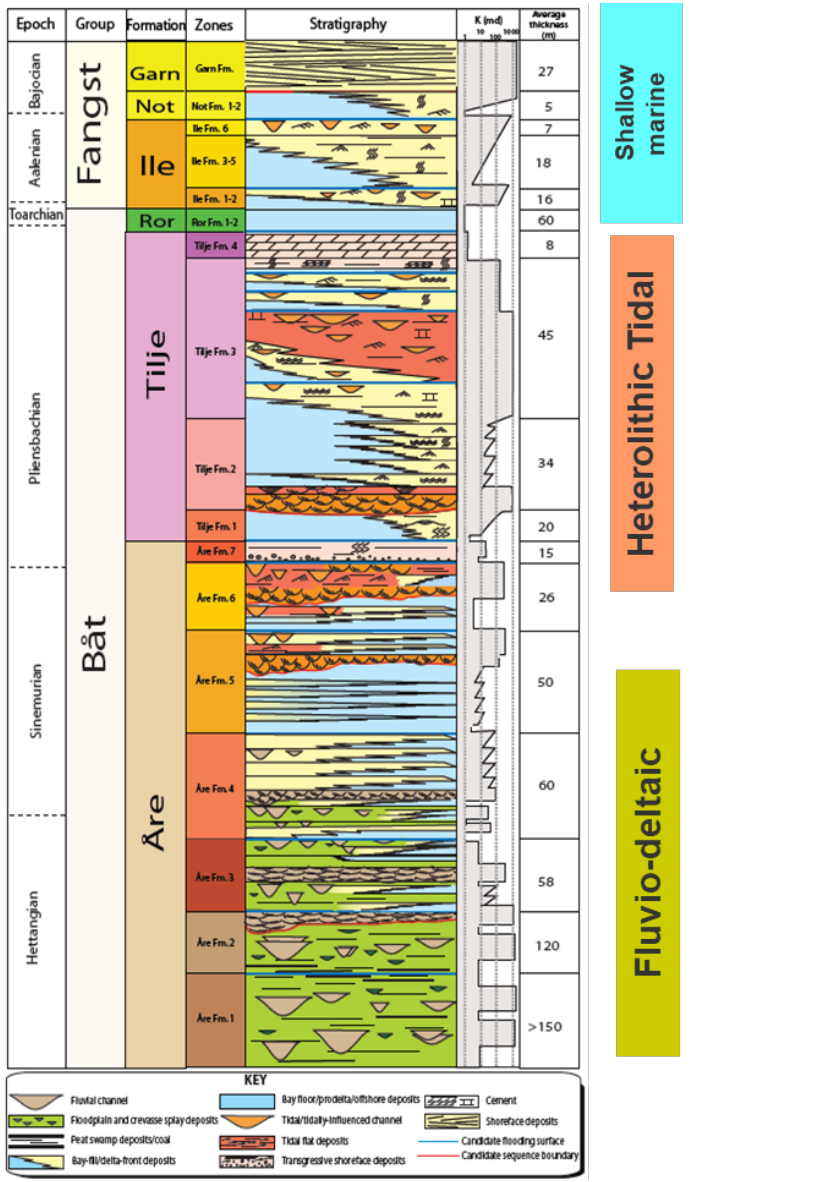
Heterolithic Tidal

Fluvio-deltaic

Heidrun IOR and well solutions

Continuously drilling new wells is key for Heidrun reserves and recovery

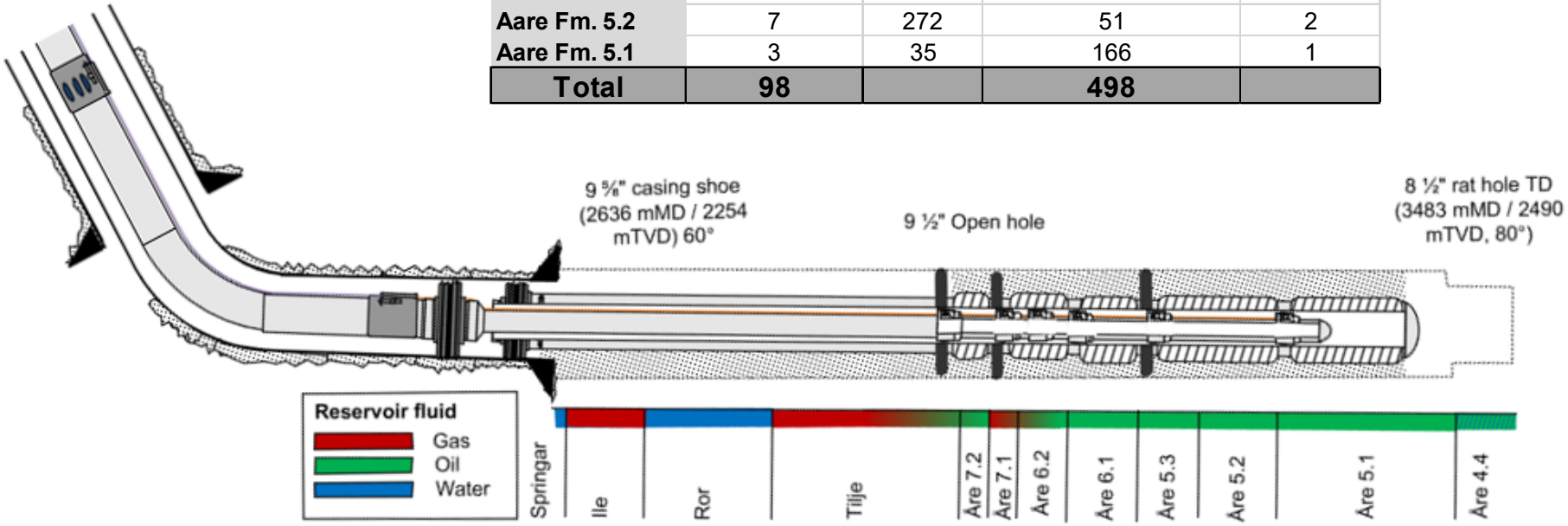
- Firm plans for drilling from the Heidrun drilling facility till 2036
- Targets will mainly be found in Lower Tilje and Åre formations
- Volumes per well targets are lower in these formations compared to Fangst
- Sand-production is a key challenge in these type of reservoirs.
- **New cost-efficient solutions is needed to ensure economical robustness**



A-4 Heidrun "Manara" Smart Completion

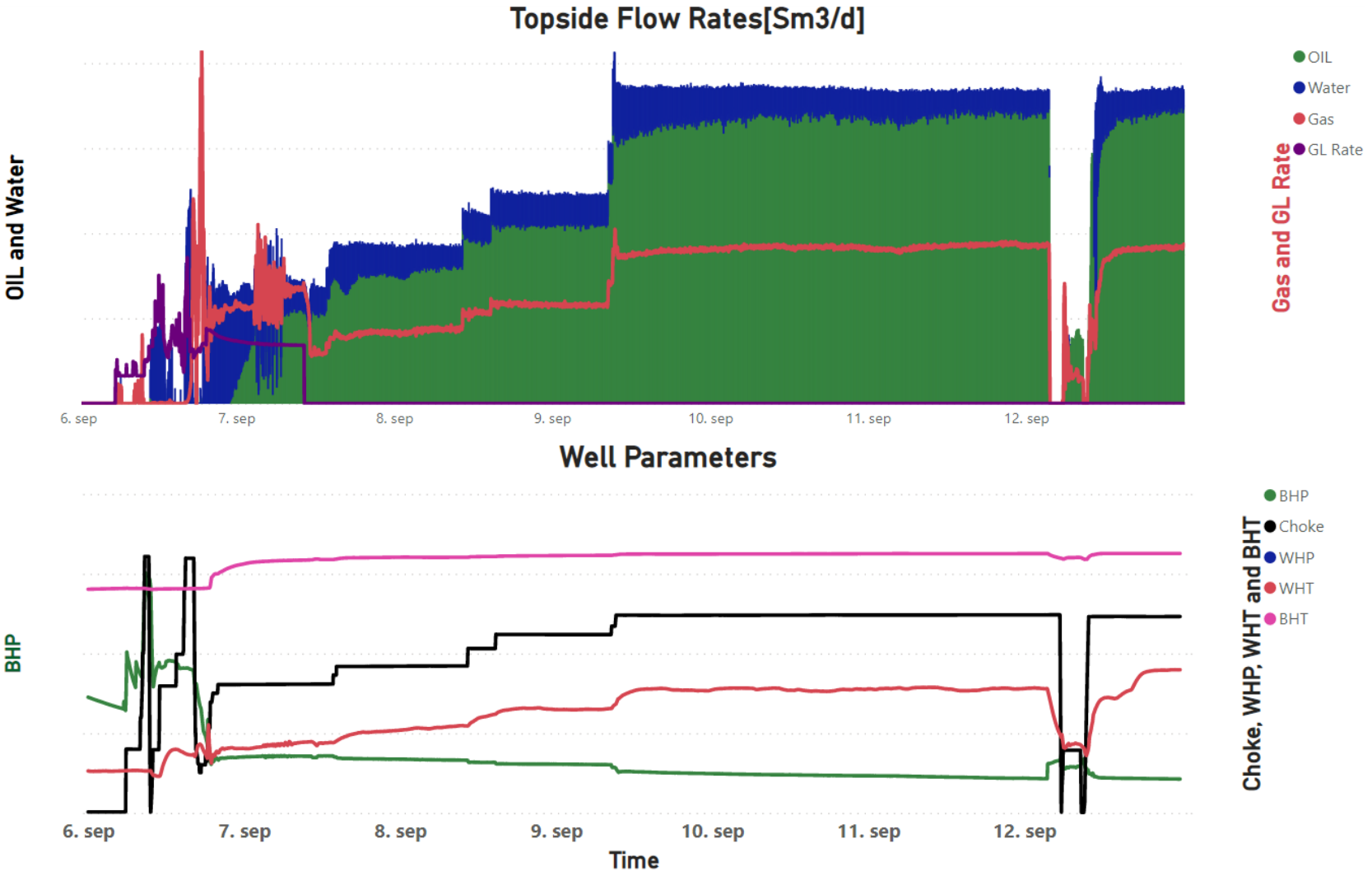
- Six inflow stations, covering eight reservoir zones
- Start-up September 6th, 2021
- Swell packers – Estimated 55 days to full seal

A-4	PI [Sm3/d·bar]	Perm [mD]	Length MD [m]	Inflow station
Aare Fm. 7.2	8	466	24	6
Aare Fm. 7.1	4	290	28	5
Aare Fm. 6.2	56	1655	63	4+5
Aare Fm. 6.1	6	133	95	3
Aare Fm. 5.3	15	504	71	2/3
Aare Fm. 5.2	7	272	51	2
Aare Fm. 5.1	3	35	166	1
Total	**98**		**498**	



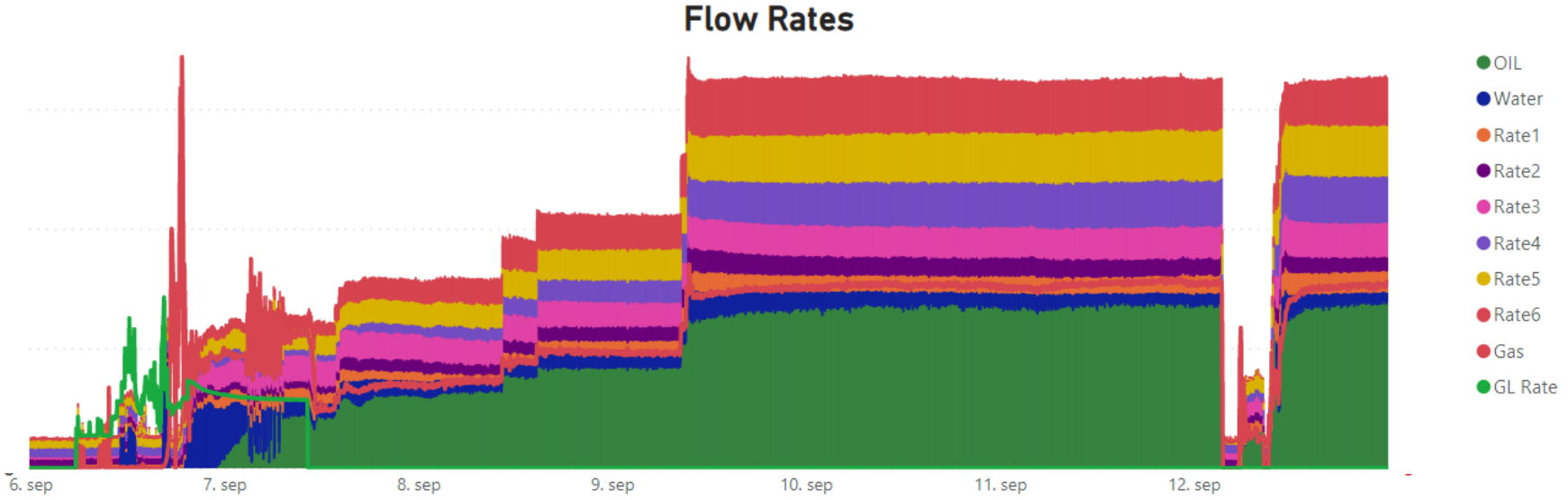
Formation	A-4 Producing zones
Upper Tilje	
Tilje 2.5	
Tilje 2.4	
Tilje 2.3	
Tilje 2.2	
Tilje 2.1.2	
Tilje 2.1.1	
Tilje 1.2	
Tilje 1.1	Inflow st. #6
Åre 7.2	|
Åre 7.1	|
Åre 6.2	Inflow st. #4 & #5
Åre 6.1	Inflow st. #3
Åre 5.3	Inflow st. #2
Åre 5.2	|
Åre 5.1	Inflow st. # 1
Åre 4.4	
Åre 4.3	
Åre 4.2	
Åre 4.1	
Åre 3.3	
Åre 3.2	
Åre 3.1	
Åre 2.2	
Åre 2.1	
Åre 1	

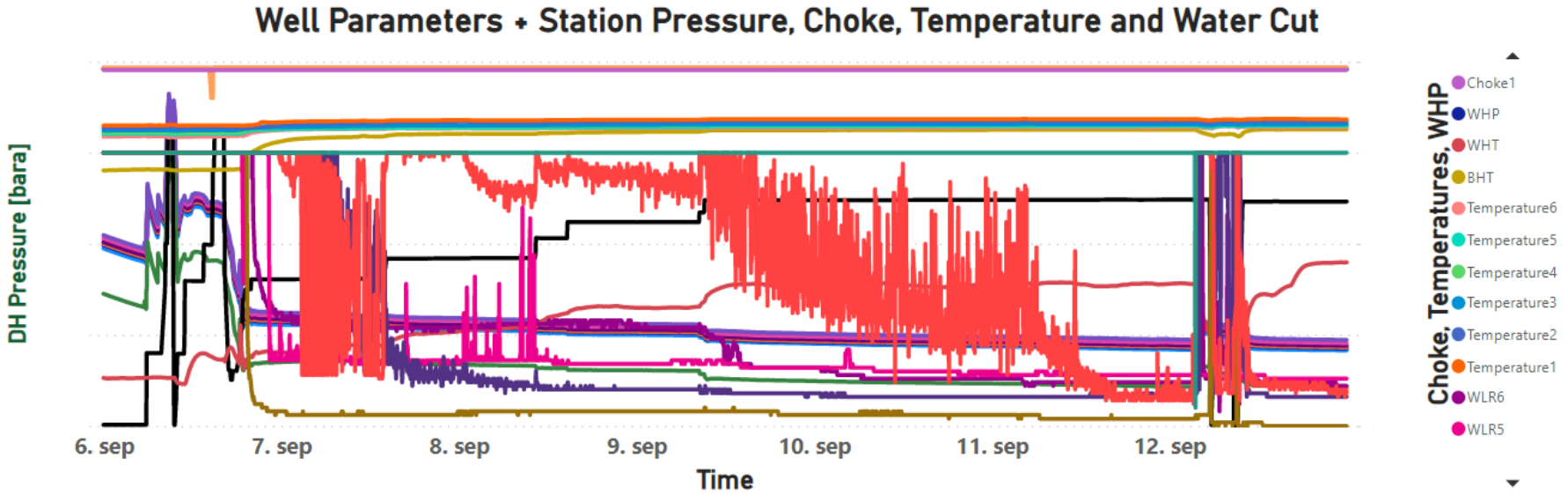
Ex # 1: A-4 Initial clean-up – Standard Well Parameters



- Standard well parameters give no information about;
  - Zonal contribution and clean-up.
- Expectation before start up
  - No initial water production
- Potential water producing zones
  - Lower part of well, Aare Fm 5.1
  - Aare Fm. 6.1 in neighboring well shut-off due to thief zone causing water/sand production

Ex # 1: Initial clean-up – Standard Well + inflow station parameters

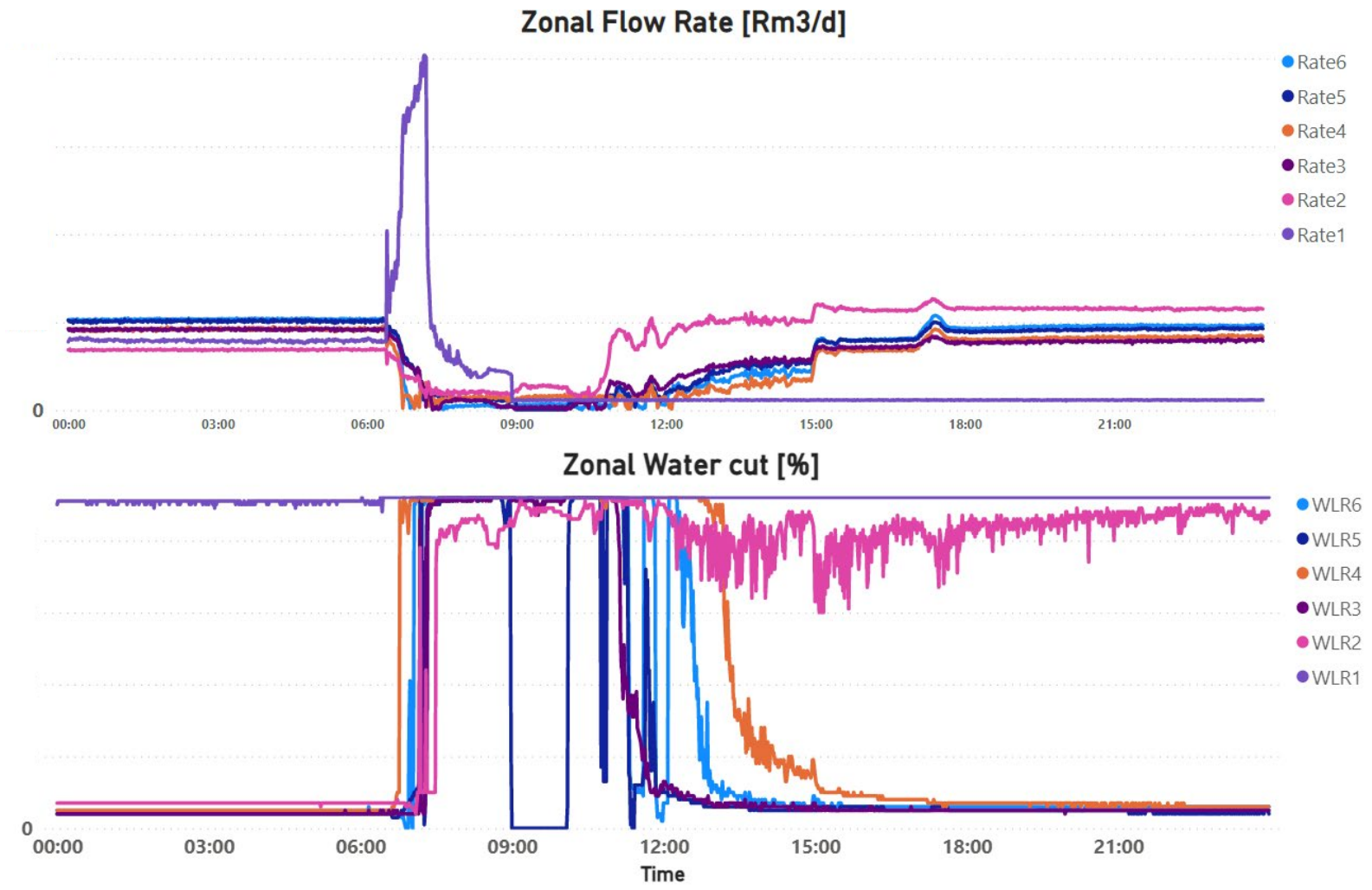




Inflow station parameters:

- Chokes
- Pressures
- Temperatures
- Rates
- Water cut

Ex 2: Sand Incident – Inflow station rates and water cuts



Sanding incident November 2021

- Station rates and water cut gives additional information
- An extreme increase of rate in station # 1 was observed
- Most likely a massive water breakthrough with high amount of sand
- Tubing filled with water + sand

Solution

- Shut-in Station # 1
- Well started up easily with GL, within a few hours
- First sample at surface, Sand volume 1,3%. Next 0,0 1%.
- Massive sand production avoided

Well A-4: Operational summary with inflow stations in the completion

Clean-up phase and production optimization

With inflow stations installed

- Zone-wise clean-up confirmed from inflow stations
- Pressure and flow development in each zone available continuously.
- Zone-wise production optimization possible.
- No intervention activity needed

Without inflow stations installed

- Zone-wise clean-up difficult to assess
- Pressure and flow development in each zone only if interventions are done (i.e., production logging)
- Limited opportunities for zone-wise production optimization

Sand control

With inflow stations installed

- Water breakthrough and associated sand production detected within minutes.
- Shutting in the correct zone enables continued production of the well.
- Sand may be produced out of the well in a controlled way

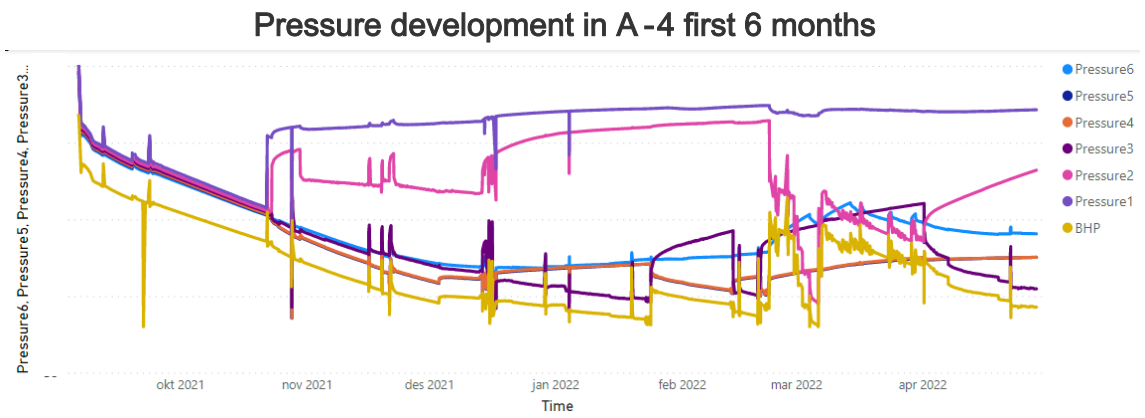
Without inflow stations installed

- Sand incidents detected from wellhead pressure/sand measurements.
- The well normally needs to be closed.
- Often an intervention (logging/bailing/plugging/straddling) is needed to get the well back in production.

Challenges and way forward for Heidrun smart well implementation

"The more you know, the more you realize you don't know." – Aristotle

- Reservoir models not necessarily ready to model development at zone-wise levels.
- Is it more beneficial to control the water?



Summary

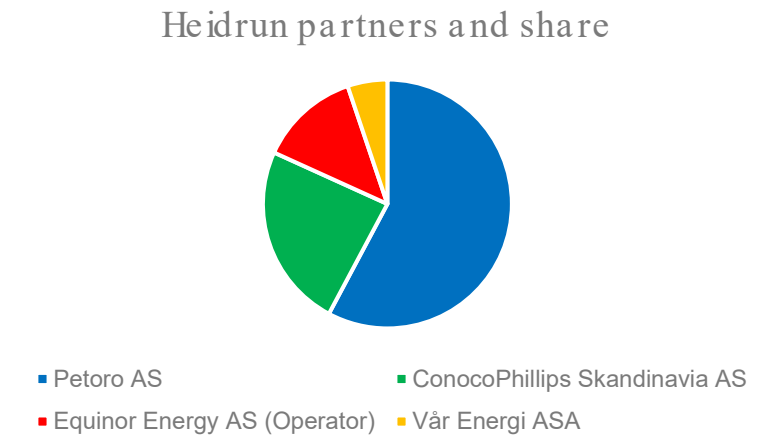
"Smart" well completions has been and are valuable parts of Heidrun's well technology toolbox.

The additional instrumentation in "modern" smart wells leads to opportunities to improve production optimization, sand management and reservoir management.

Next step for Heidrun is to install similar technology in a water injector to enable targeted water injection.

The further use of the smart well technology is evaluated continuously based on cost-benefit analysis.

Acknowledges to Heidrun partners for permission to present this in the NPD Teknologidag 2023:



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