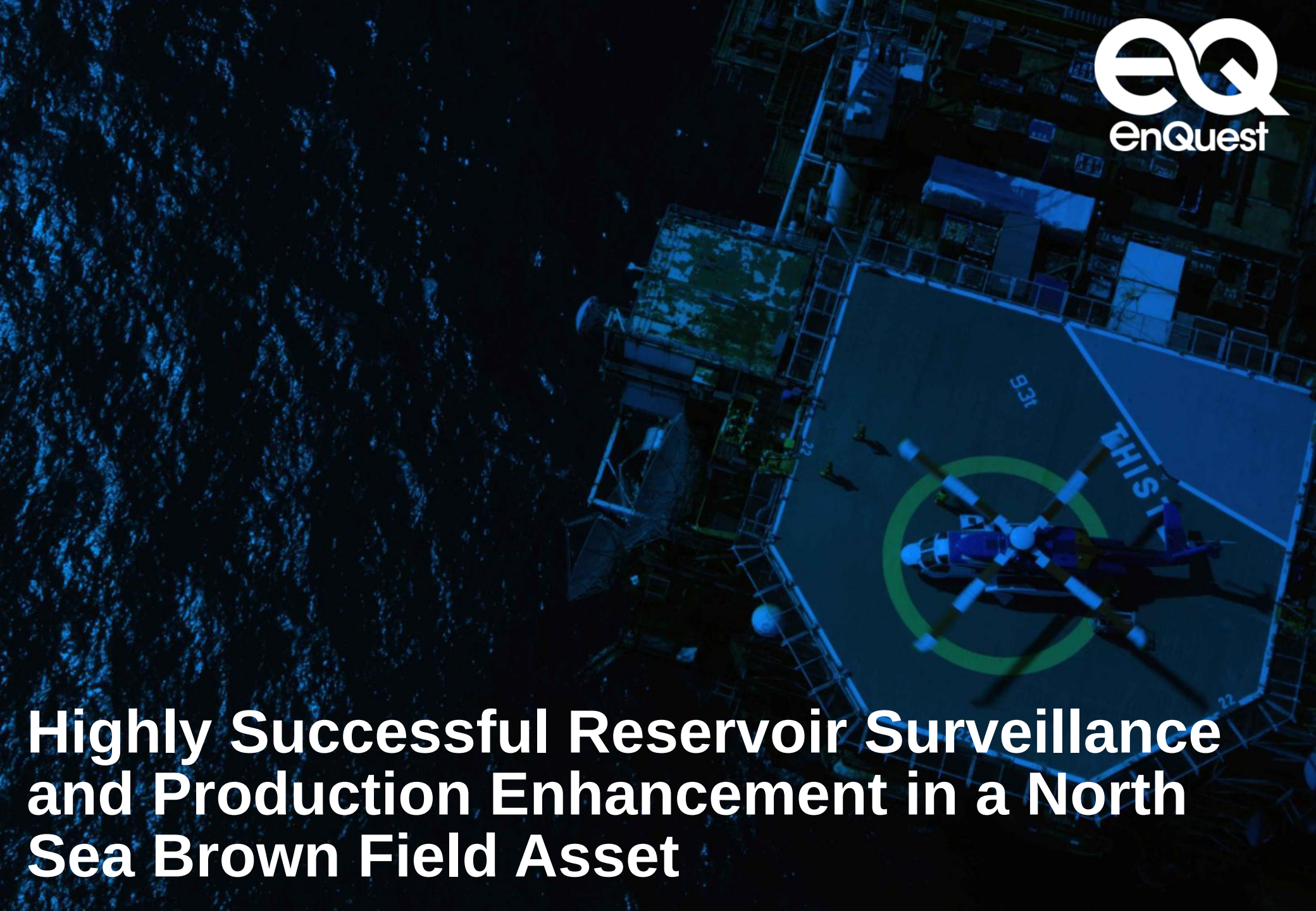


Highly Successful Reservoir Surveillance and Production Enhancement in a North Sea Brown Field Asset

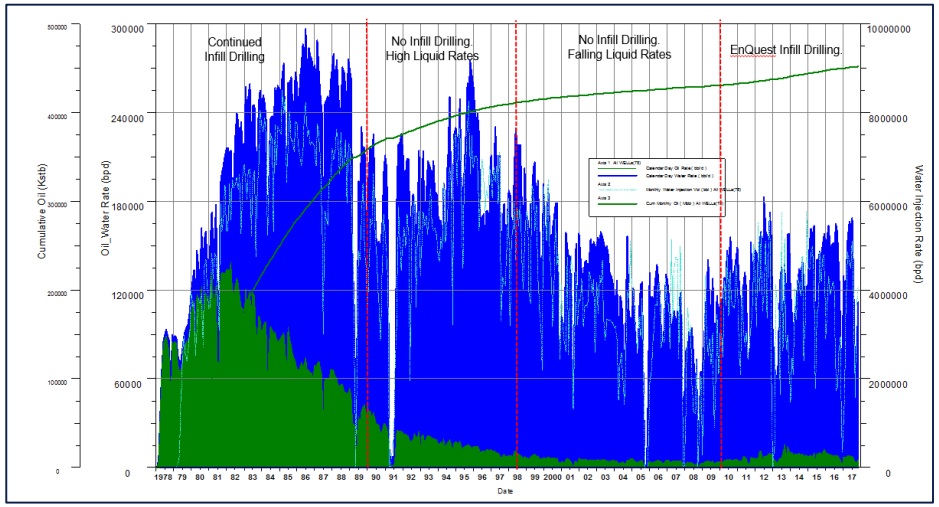
Thistle Field Summary

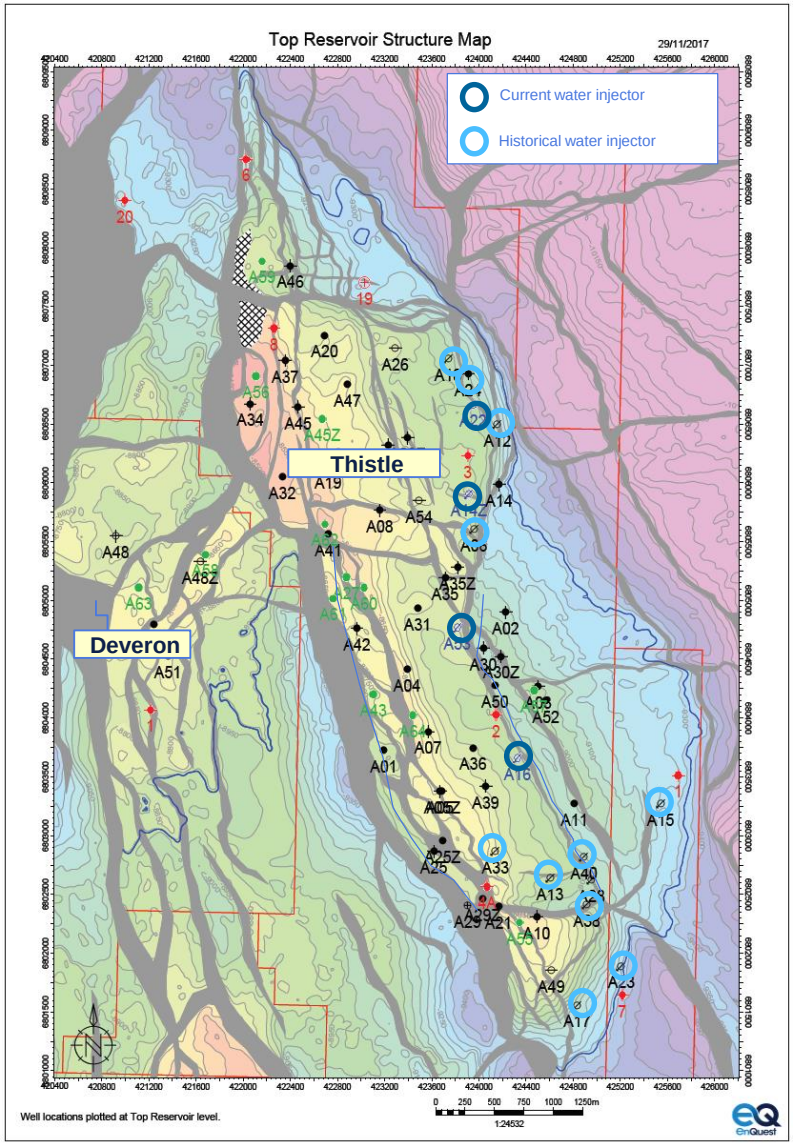
Thistle Field

- Northern North Sea oil field.
- Brent Group reservoir.
- First production 1978 (75 well penetrations).
- 11 current active producing wells (2 ESP wells).
- 4 current active water injectors.

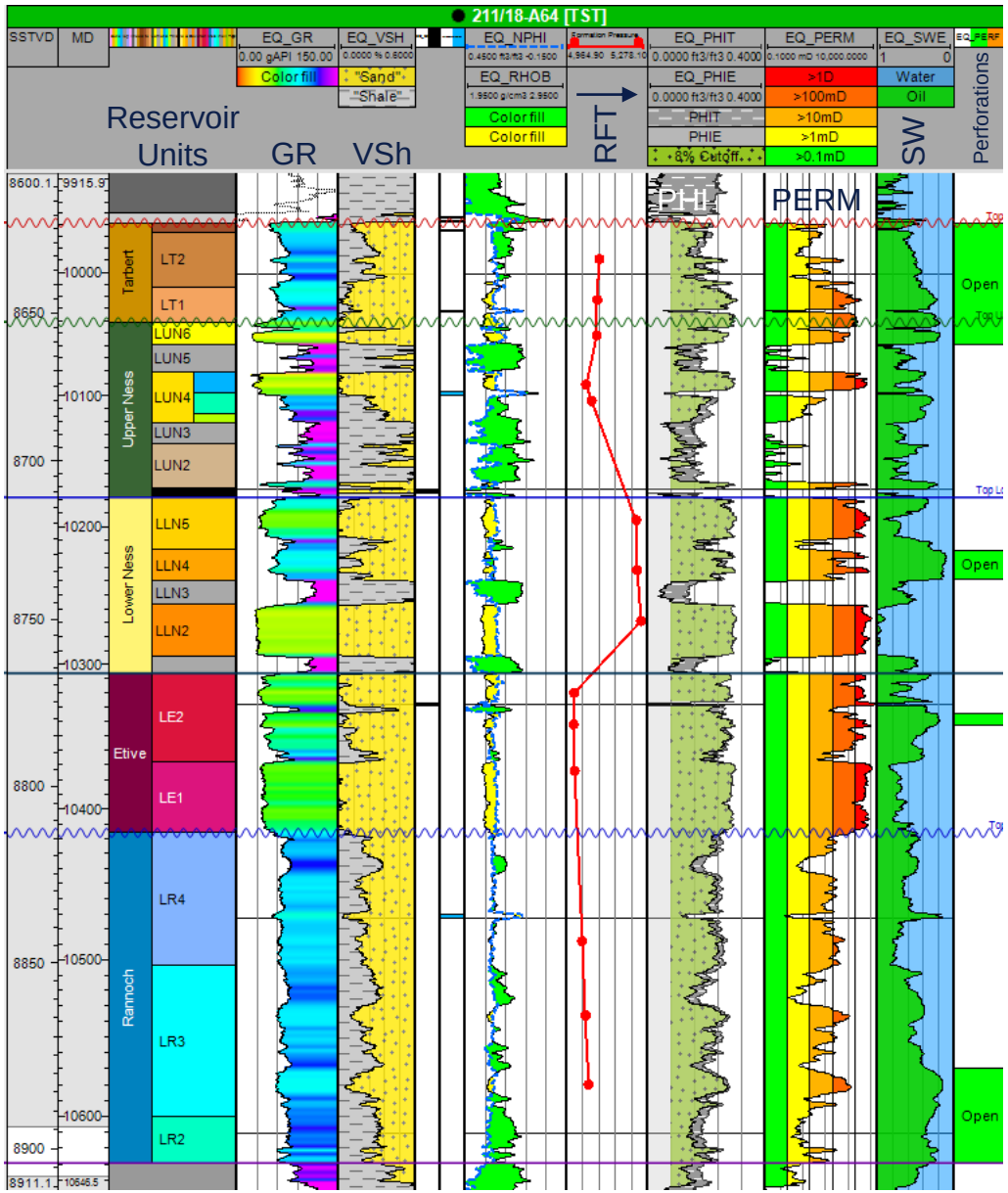
- Cumulative Production: 430 mmstb
- STOIIP: 741 mmstb (58% RF)
- EMPP at start of campaign: ~7,250 bopd (hub rate)

- Oil Properties:
- API 38 API
- Bubble Point 920 psig
- GOR 282 scf/stb





Reservoir Summary



Logs open hole unless otherwise indicated.

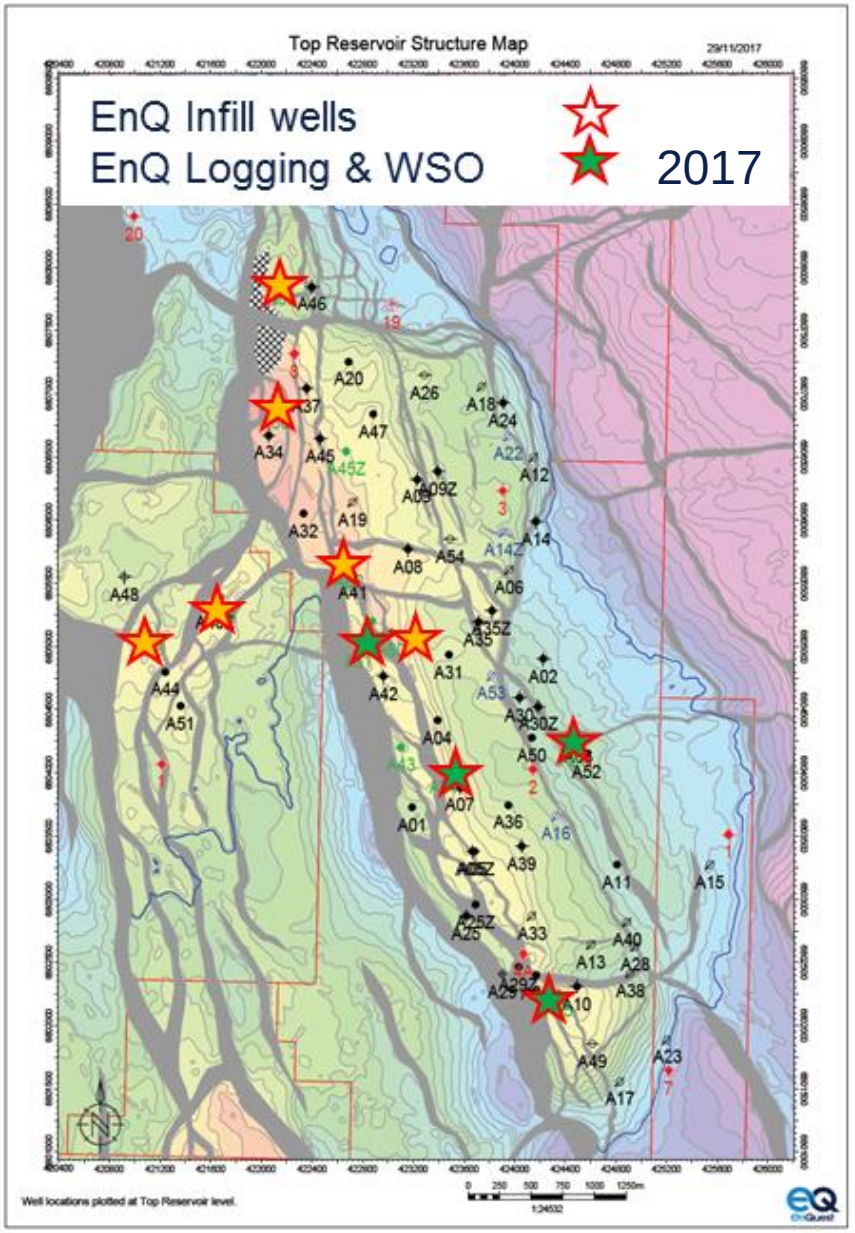
Middle Jurassic, Brent Group reservoir.

Reservoir comprises Rannoch, Etive, Ness & Tarbert Formations.

- Rannoch & Tarbert
  - Storm dominated shoreface deposits.
  - Sandstone with varying mica content.
  - Typical net permeability 3-700mD.
- Etive
  - Fluvial complex.
  - Clean sandstone, diageneically altered sands, coal, shales.
  - Typical net permeability 100-5,000mD.
- Ness
  - Fluvial & fluvially influenced shoreface deposits.
  - Sandstone, siltstone, shales, coals.
  - Typical net permeability 1-4,000mD.

Layered reservoir perforated in a staged manner.

Background to Logging & Intervention Campaign



- 10 infill wells drilled by EnQuest between the years 2010-2016, wells 211/18-A55 to 211/18-A64.
  - First wells since 1995
- The Thistle Field has been supported by water injection since 1979. The field is currently at high watercut, ~95%.
- In 2017 the asset focus was to optimise base production from the existing well stock.
- Aim to identify and shut off dominant high water cut layers in targeted wells. Enhances production from poorer supported, lower water cut units.
- Shutting off water not only decreases watercut at a given well, but also reduces gross liquid throughput in the processing plant.

CONTEXT

- **Plant has been water constrained at high reservoir pressure**
- **Focus is on maintaining voidage**
  - Can inject 180-200 mbwpd
  - Thistle ~ producing 150 mblpd
  - Uptime of production vs. injection system critical
  - Looking for more efficient sweep
- **Wells are tubing constrained – often 15-25 mblpd**
  - Water shut-off objective to increase drawdown on lower WC layers
  - High quality reservoir – reduced ‘h’ not significantly affecting flow rate

- **Incentivised contract with vendor provided full basket of tools over a fixed number of days**
  - Took: guns, Interwell plugs and straddles for immediate intervention if opportunity found
    - Makes for dynamic and cost efficient campaign
  - Contract was a key success factor, as all parties looking for a good outcome
  - Advanced tools changed a straddle decision – discussed later

Thistle Logging & Intervention Campaign Summary

- Four well logging and water shut off campaign undertaken in 2017.

- Despite high water cut in wells (95%+) & moderately deviated wellbores (50°+), intervention logs captured clear water shut off opportunity in each well.
  - Cases of high water rate (>10,000bwpd), high water cut (>99%) layers hindering production from lower water cut layers.

- Shutting off these layers led to a campaign sustained uplift of over 1,000 bopd.
- Finished year at higher rate than we started

- Additional opportunities in remaining wellstock will permit a future campaign.

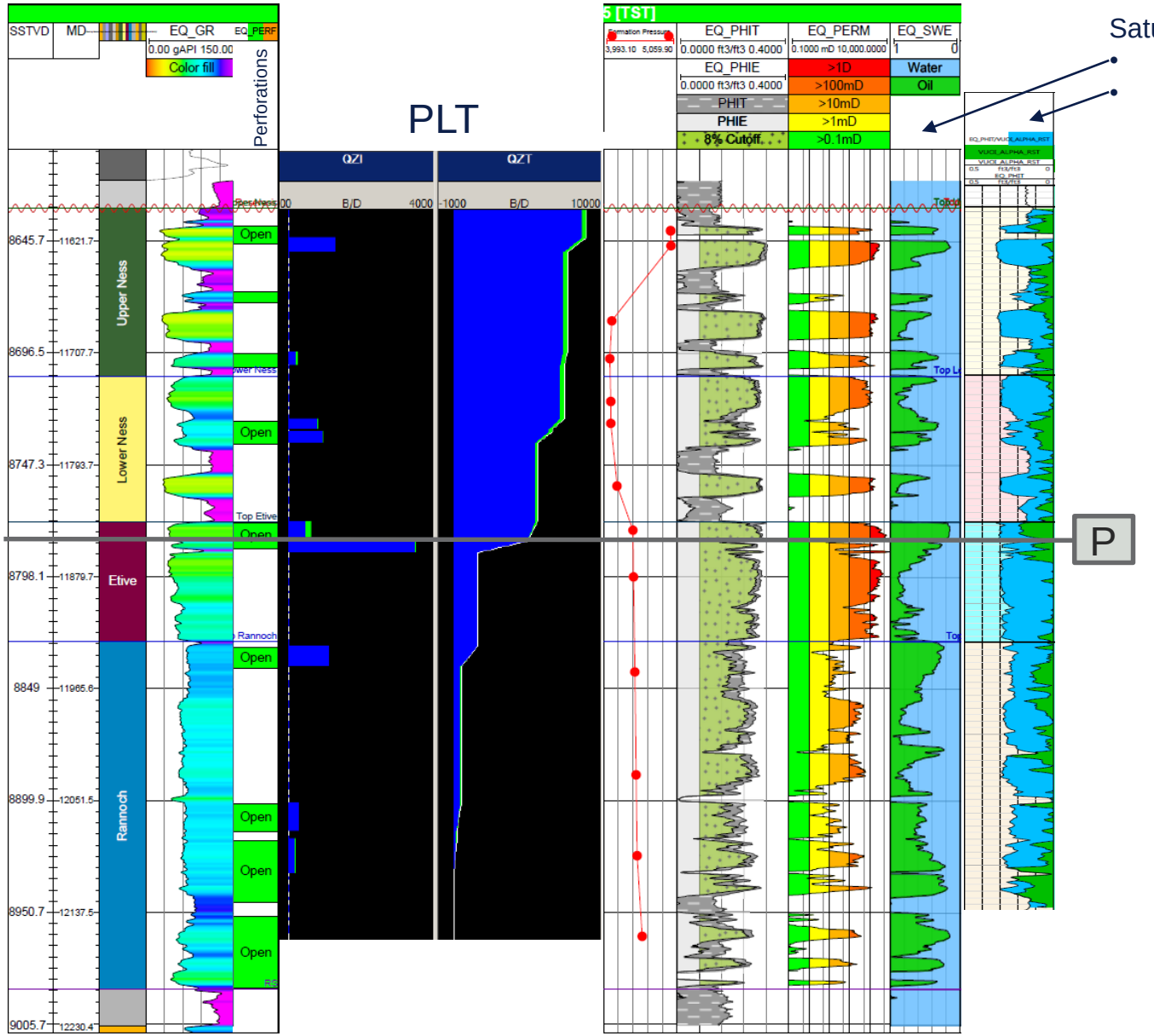
- Data obtained also informs on the gains that could be obtained from further extension of artificial lift.

- Data obtained also aids in subsurface studies work. Informs on layer contribution in various areas of the asset.

Interventions Work Scope Summary

WELL	Tractor	MFC	PLT Pre WSO	PLT Post WSO	Saturation Log	Plug	Straddle
A55		✓	✓		✓	✓	(✓)
A57		✓	✓	✓	✓	✓	
A61	✓	✓	✓			✓	(✓)
A64	✓	✓	✓		✓	✓	(✓)

A55 Intervention Logging Results Summary



Saturations
- 2010 Open hole
- 2017 Saturation log

- Significant oil production from upper Etive. Lower Etive gives highest gross liquid & watercut contribution.
- WSO identified
  - Unable to set straddle in Ness due to liner deformation. This was identified by multi-finger caliper log.
  - Plug set in Etive.
- Post plug uplift of 400bopd.

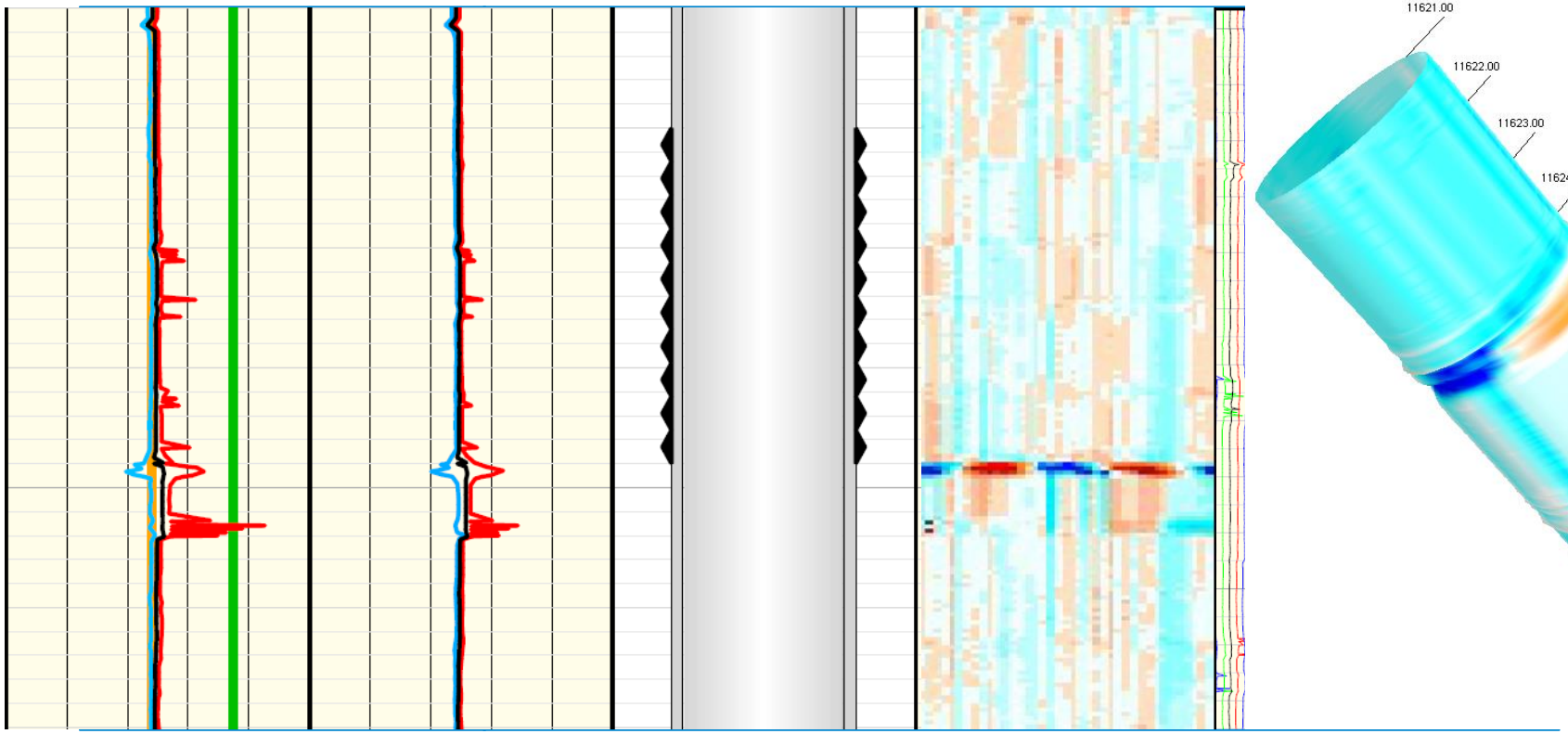
Logs open hole unless otherwise indicated.

A55 Liner Integrity Learnings

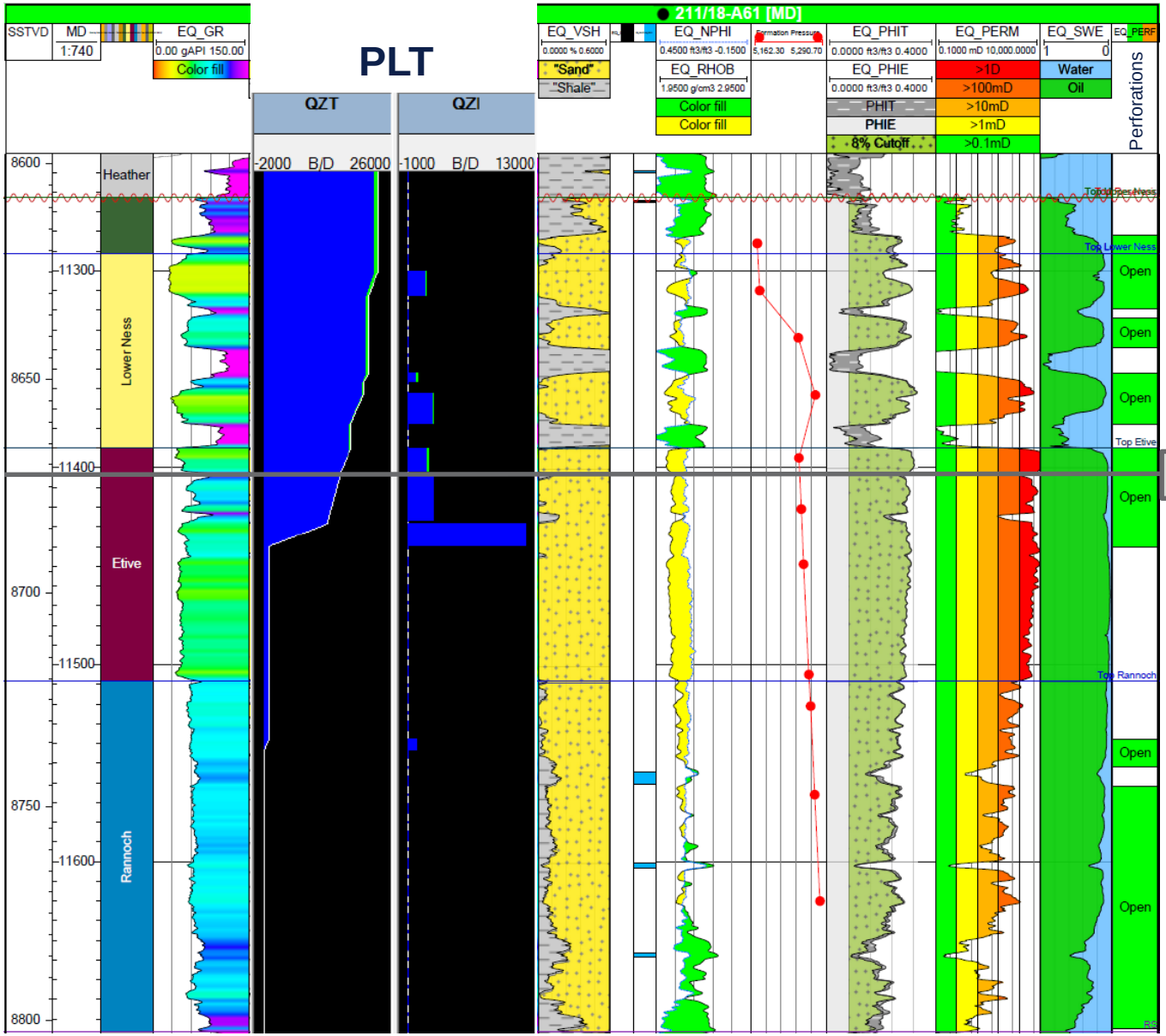
MFC data was used to confirm Liner integrity and Perforation depths.

Top perforation shows a small depth difference verses planned. This helped to ensure the inflow zonal production is allocated to the correct flow unit.

Liner pinch point was noticed towards the bottom of the first perforation. Data was used to ensure further runs are modified for operational risk mitigation.



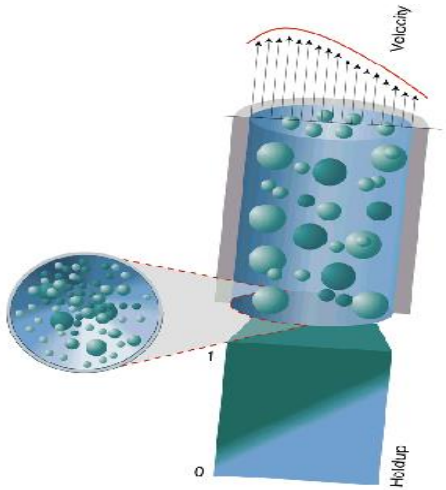
Thistle A61 Logging & Intervention Campaign Results



- Logging showed 8 flow units within the well.
- The Rannoch, lower & mid Etive were at 95-100% watercut. The lower Etive was flowing at over 12kbwpd.
- The decision was made to set the plug at mid-Etive.
- Prior to setting the plug the PLT recorded flow rate of 760bopd from A61.
- The initial oil gain from setting the plug was in excess of 1,000bopd.

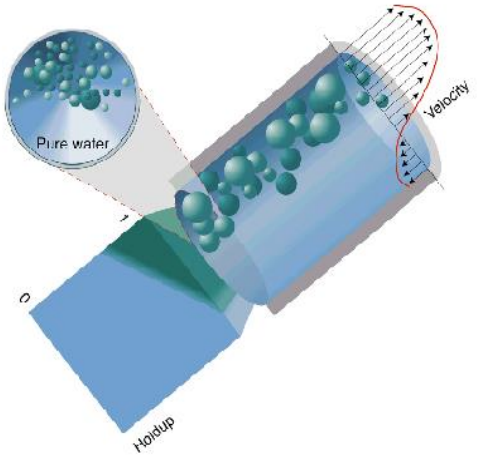
Logs open hole unless otherwise indicated.

Flow Regime and Impact on PLT Tool Selection



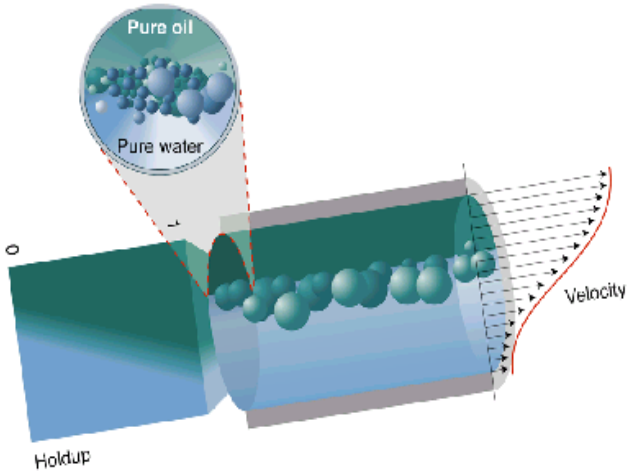
Vertical

- Relatively simple flow regimes
- "Standard" PLT measurements adequate. These include full bore spinner, pressure, temperature, density and auxiliary measurements



Deviated

- More complex flow regimes if 2 or 3
- phases are flowing downhole
- Start to see phase segregation and
- re-circulation of heavy phase.
- Deviation as low as 20 degrees enough
- to cause issues. Complexity is a function
- of well deviation and flow rates.
- "Local" measurements needed

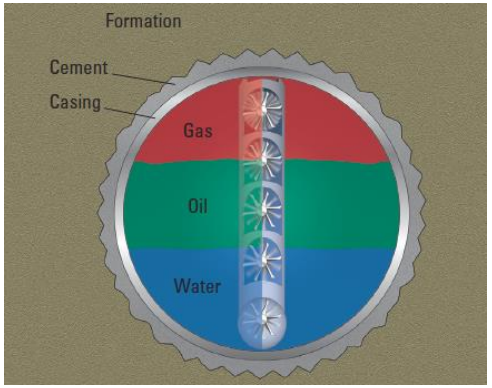


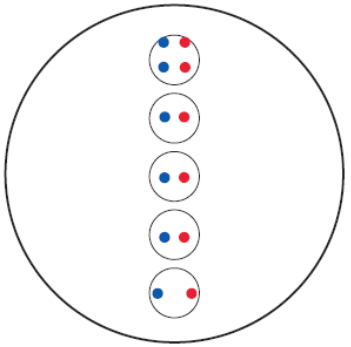
Horizontal

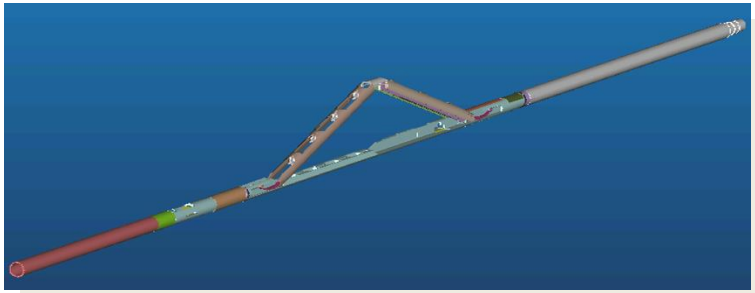
- Stratified flow, thin mixing layer
- Average measurements not sufficient
- Need for independent phase holdup and velocity measurement

Advanced PLT Tool for Deviated/Horizontal wells

- **Velocity** and **Holdup** measurements for 3 phases along vertical cross section of borehole.
- **All sensors** measure the **same section** of the well at the same time due to optimized tool length.
- **Fewer logging passes** needed leading to significant reduction in overall intervention costs.
- **Real time data validation** and answer product.
- **Combinability** with other tools: MFC, Saturation Log, Tractors etc.

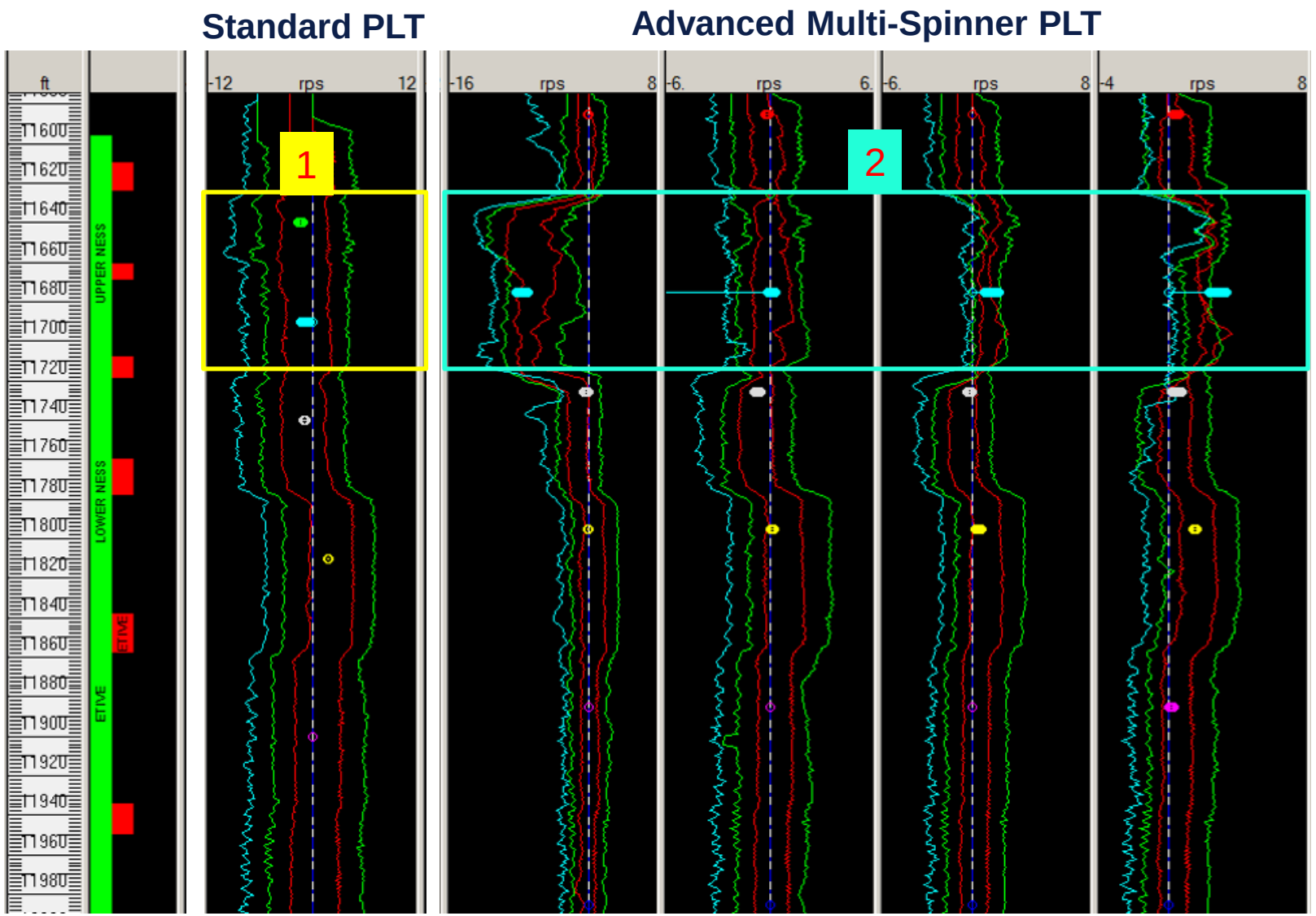






6 Yg Optical Probes
6 Yw Electrical Probes
5 Miniature Spinners

A61 PLT Learnings – Accurate Velocity Regime



1. Standard PLT single spinner tool is not able to measure the flow across the fullpipe cross-section.

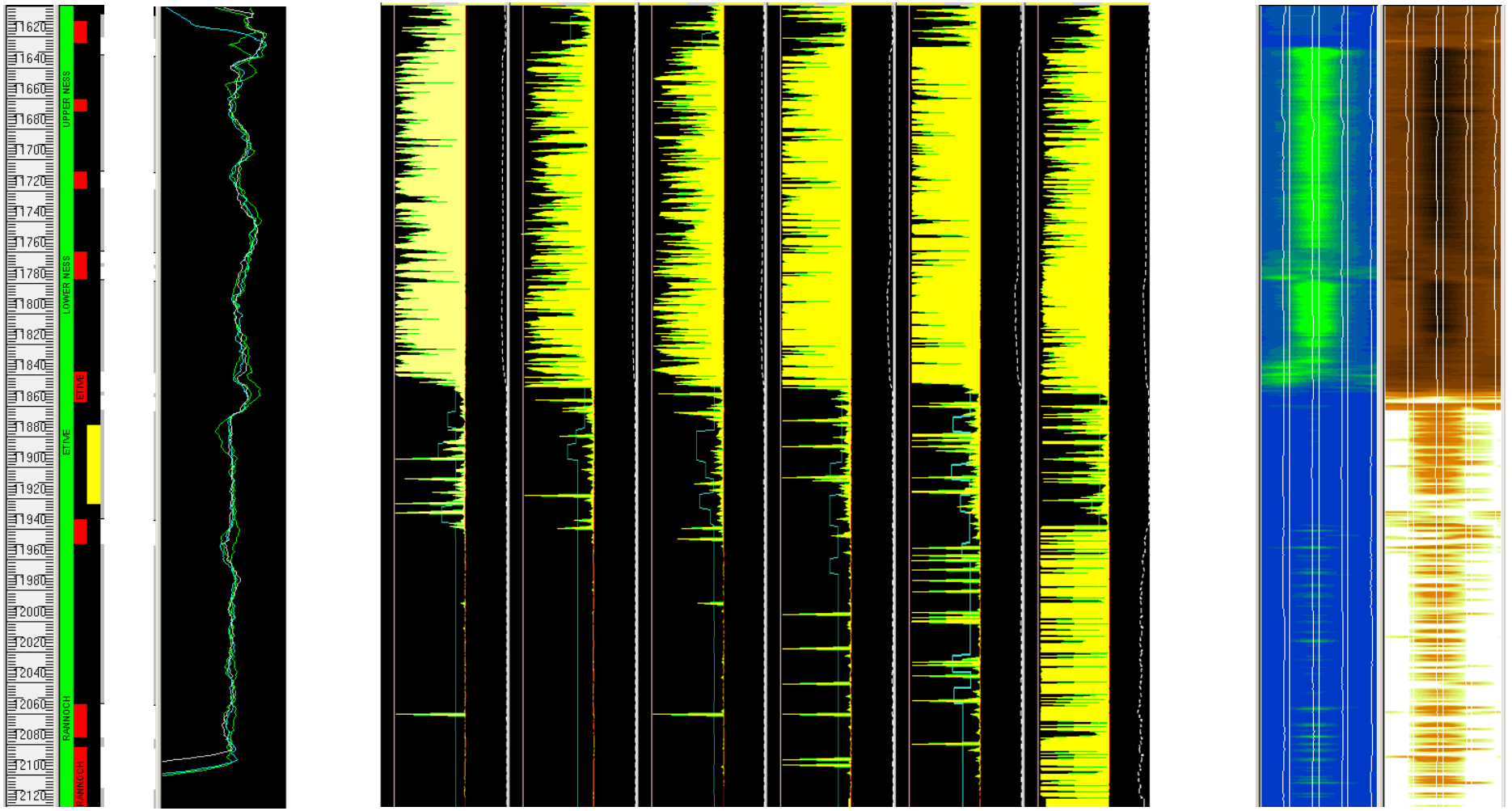
2. Advanced Multi-Spinner tool provides clarity – Lower most spinner shows recirculation up/down flow on the low-side, whereas the spinners on high-side shows UP flow.

A61 PLT Learnings – Accurate Holdup Measurement

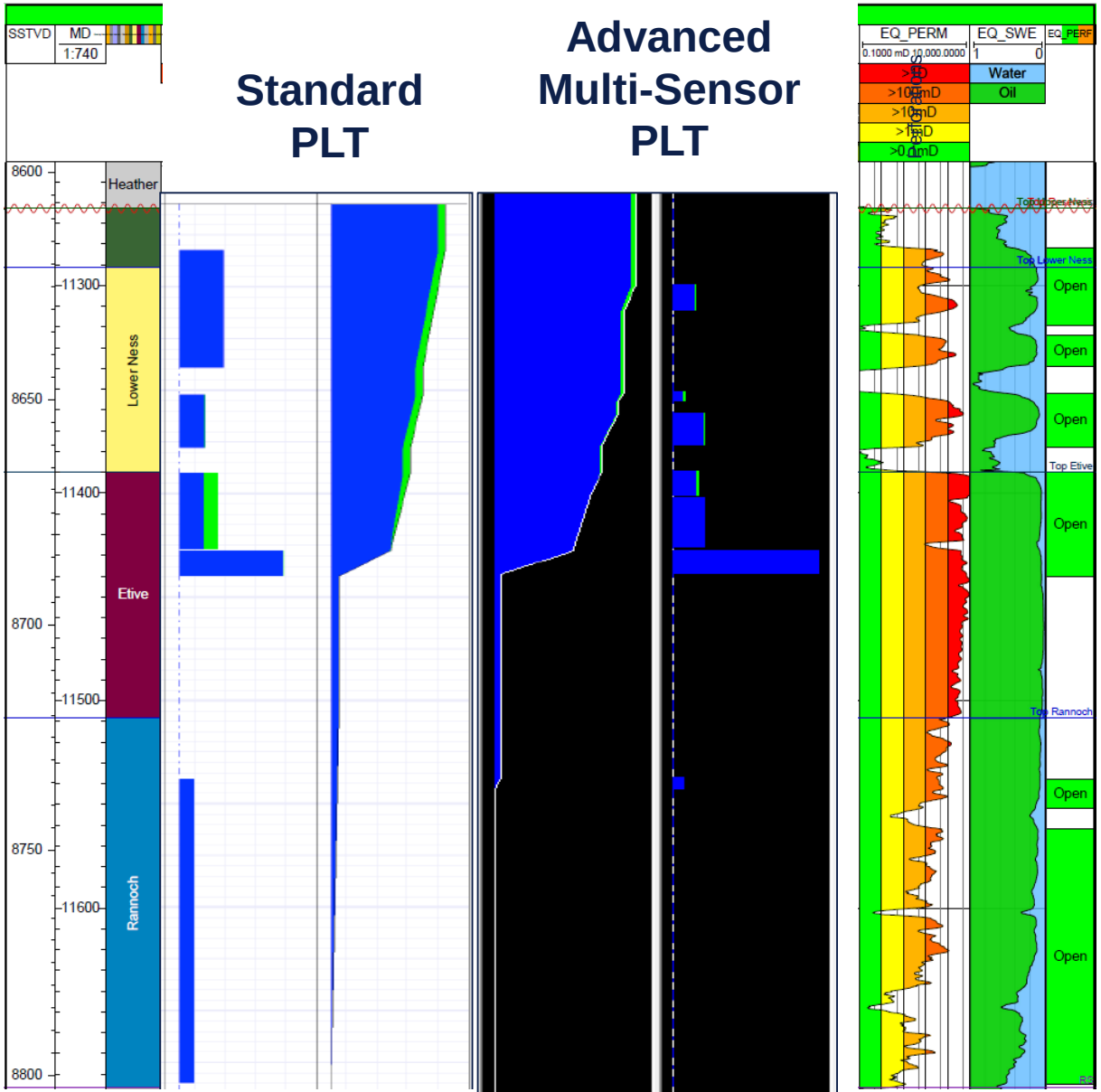
Well Fluid Density

Direct and Accurate measurement of Water and Hydrocarbon Holdup using Advanced PLT tool

Flow regime based on multiple holdup sensors



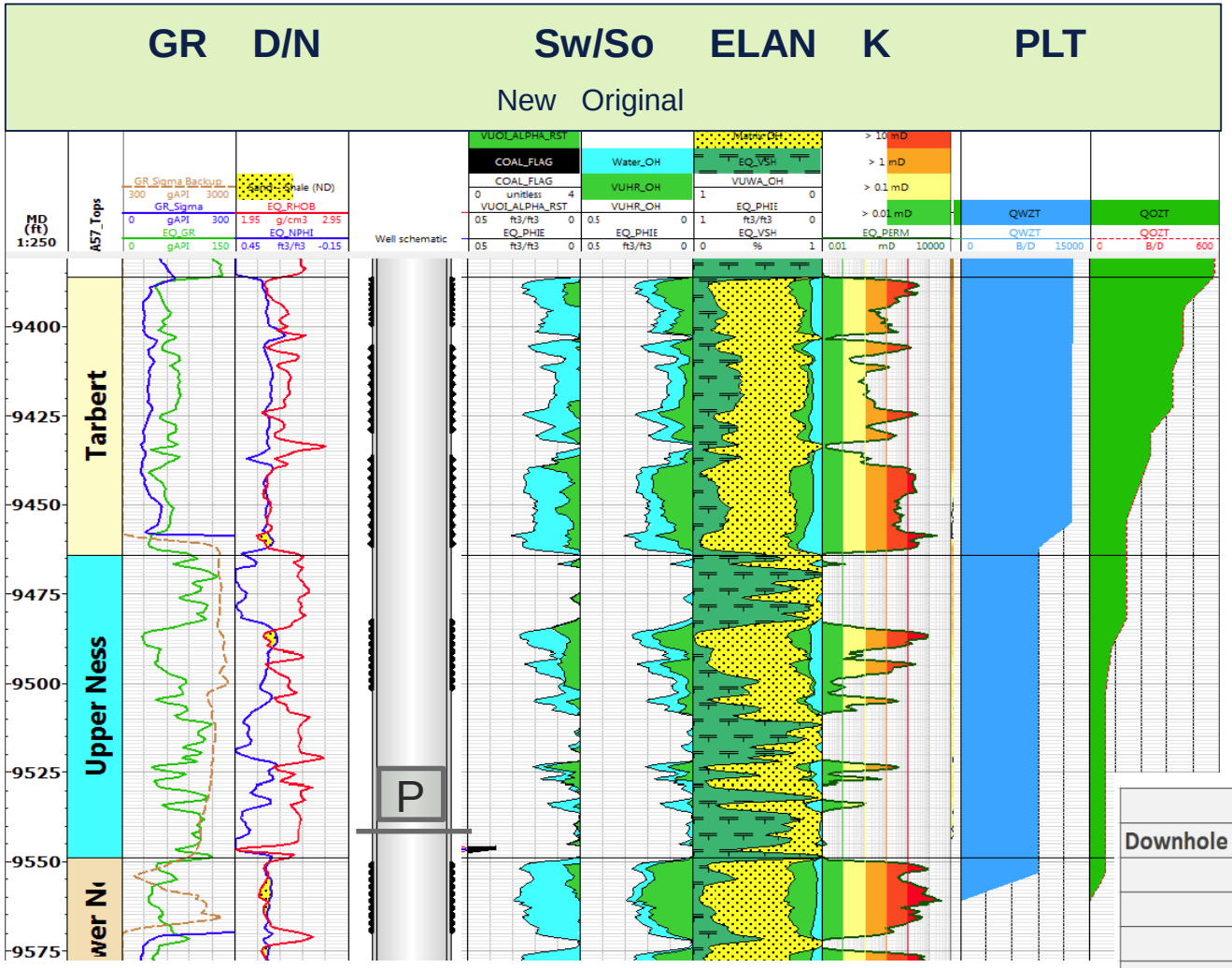
A61 PLT Learnings



- This example further demonstrates the importance of selecting the right PLT tool for the objectives and well environment
- Standard single spinner PLT data was acquired in previous years and compared with Advanced PLT multi-sensor results
- Based on data, had planned for plug and straddle
- The WSO shutoff decision based on standard PLT would have been wrong

Logs open hole unless otherwise indicated.

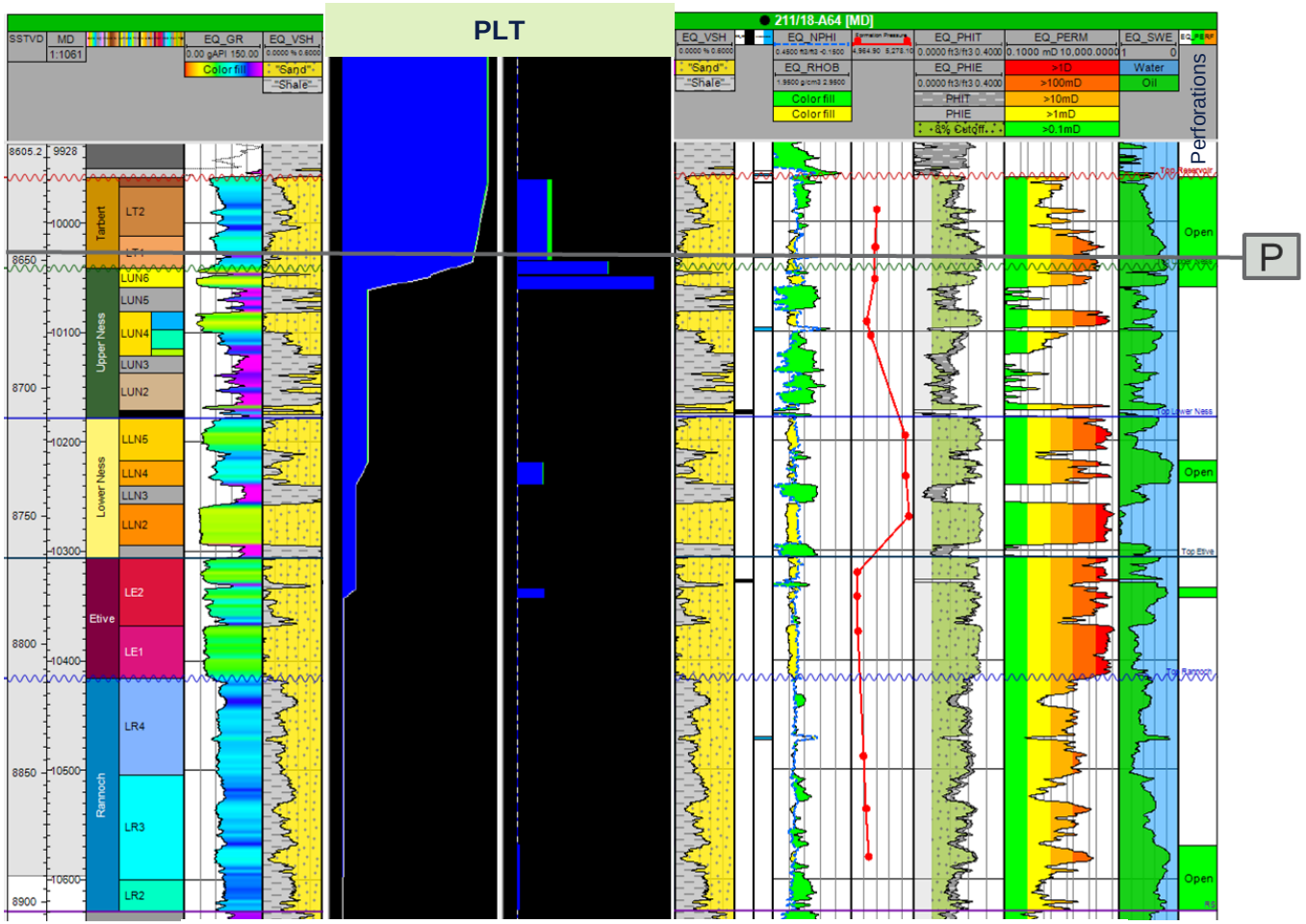
Thistle A57 Logging & Intervention Campaign Results



- Only upper Brent logged as lower Brent in water leg.
- Highest water cut zones were Lower Ness and lowest Tarbert.
- Lower Ness perf target swept
  - Behind pipe flow
- Plug set above Lower Ness.
- Initial uplift of >600bopd

		PreWSO	PostWSO	% Change
Downhole	Oil rate	577.1	1,255.0	117.5%
	Water rate	12,966.4	8,747.5	-32.5%
	Liquid rate	13,543.5	10,002.5	-26.1%
	Pressure	4,357.0	4,083.0	-6.3%
	PI (B/D/psi)	46.4	15.6	-66.4%

Thistle A64 Logging & Intervention Campaign Results

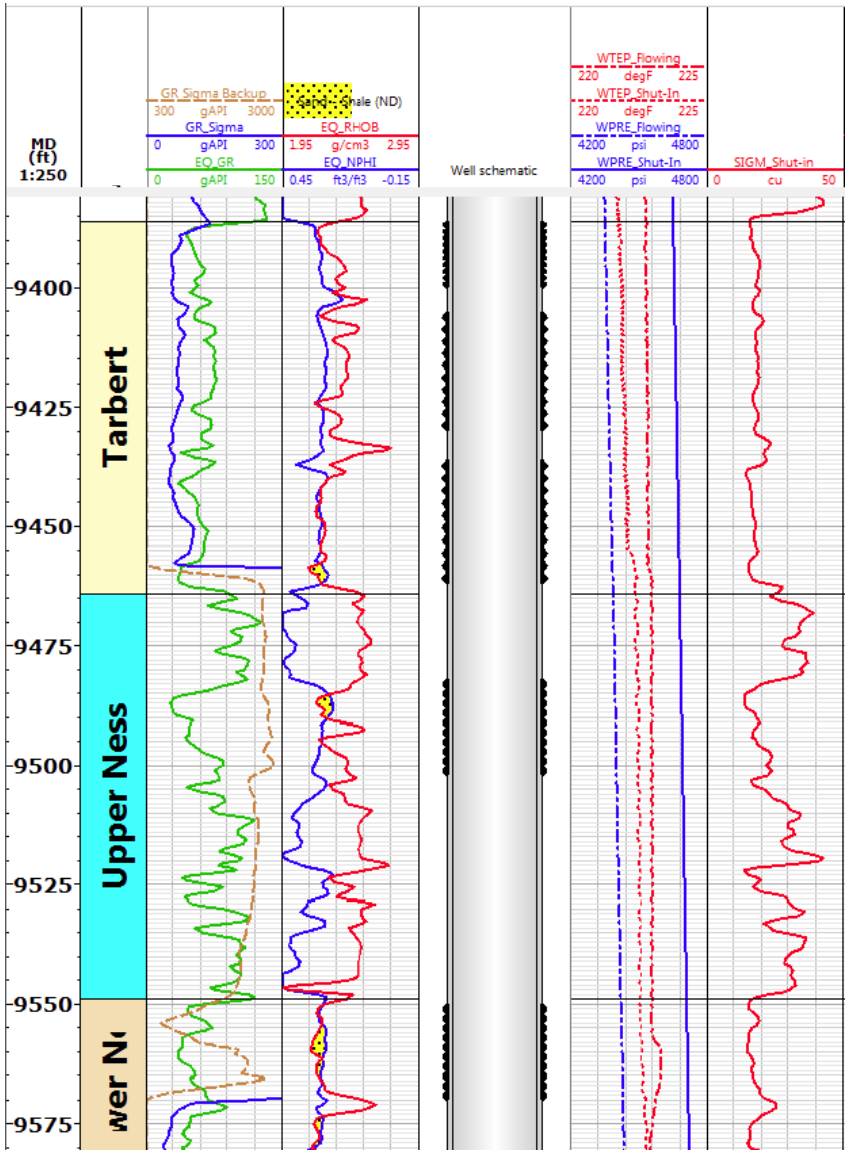


Logs open hole unless otherwise indicated.

Zones ft	Qw res. B/D	Qo res. B/D	Qg res. B/D
Inf. 1 (9959.0-10032.0)	2179.65	263.04	0.00
Inf. 2 (10034.0-10045.5)	6467.86	21.74	0.00
Inf. 3 (10047.6-10059.1)	9773.84	18.94	0.00
Inf. 4 (10218.0-10238.0)	1815.81	15.39	0.00
Inf. 5 (10334.0-10343.0)	1900.15	0.00	0.00
Inf. 6 (10570.0-10629.0)	127.55	0.00	0.00

- Most of the oil was coming from the Tarbert Formation. Ness producing at the highest rate & ~99% watercut.
- Despite encouraging opportunity identified during logging, post intervention evaluation couldn't identify any uplift in oil rate.
- Correlation believed good, plug setting was text book
  - No CBL available – but poor cement hypothesised as cause
  - Some evidence on temperature log

A64 Tool & Correlation Learning



High GR noted in some wells.

CCL signal not clear due to scale.

In this example, the natural GR is very high (up to 2500 gapi) – seen as Blue/Brown curve in track-1 – compared to original GR (green).

Correlation for logging data and remedial WSO (plug or Straddle) becomes very challenging.

PNC Sigma (last track) correlates very well with original GR and ensured depth correlation.

Plug/Straddle run should have both GR and CCL to correlate to PLT or Saturation on depth data.

Conclusions

- Intervention was undertaken in each well. Three out of four interventions provided an oil uplift.
  - A61 paid back whole programme cost before campaign had been completed.
  - Hub oil rate improved by 15%. Water flooded area improved by 36%
- Integration & collaboration between operator & vendor worked very well & proved vital during detailed and complicated operations.
- Operations were successfully executed without any HSE issues.
- Level of reservoir layering detail beyond what was expected.
- Fit for purpose tools successfully identified inflow profile & current saturation in complex layered reservoir.
- The data gathered during the logging & intervention campaign cemented & enhanced understanding of reservoir performance and has pointed toward future opportunities.
- Next 4 well campaign approaching “Define” stage gate