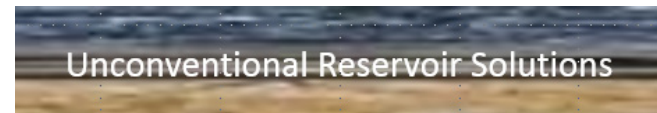


# Next steps to crack the code on tight Permian Toolachee and Patchawarra sandstones of the Cooper Basin, southwest Queensland

Ray Johnson, Jr., Unconventional Reservoir Solutions

Lan Nguyen, Terry Russell, Real Energy

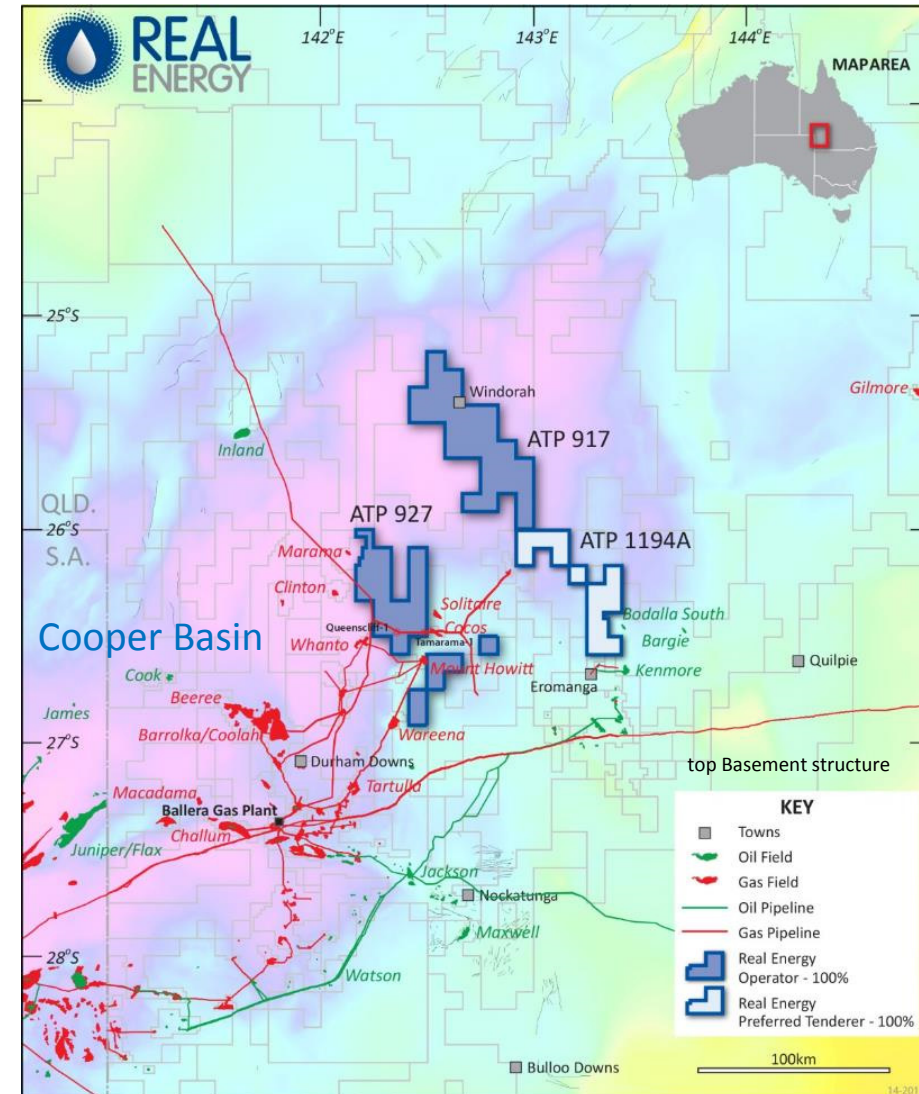


# Content

- Background
  - ATP 927 Location
  - Structural setting of the Windorah Trough
  - Reservoir and play concept
- Data collection and design optimisation workflow
  - Pre-frac logs
  - DFIT data
  - Stress profile construction
  - Optimised frac design
- Recent ATP 927 activity
- Future recommendations
- Summary

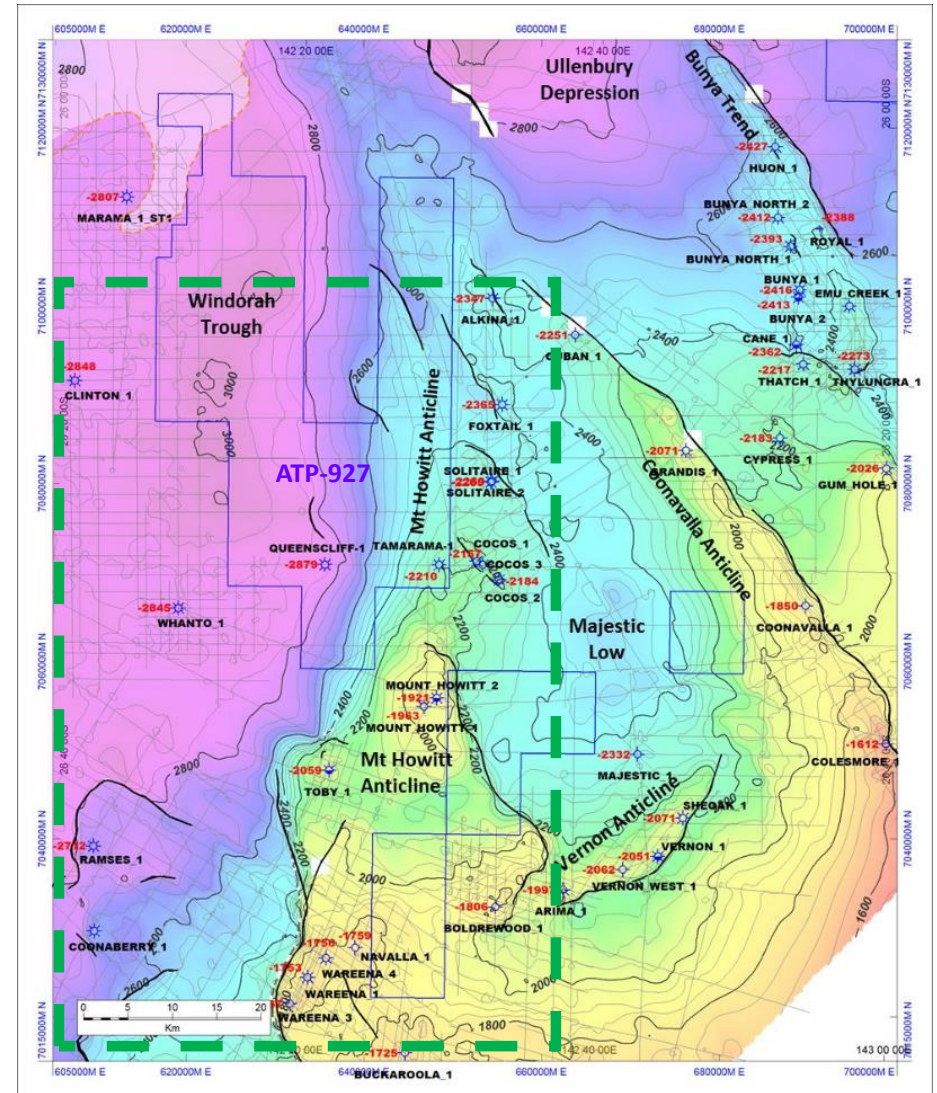
# ATP 927 Location Map

- ATP 927 is located in the SW Qld sector of the Permo-Triassic Cooper Basin
- Gas discoveries in Cooper Basin reservoirs have been made on structural trends adjacent to ATP 927
- Real Energy drilled, completed and tested Tamarama-1 and Queenscliff-1 with gas flow to surface from the Upper Patchawarra and Toolachee Fms after tubing-conveyed, underbalanced perforating
- Both wells were drilled at locations independent of structural closure



# ATP 927 Structural Setting

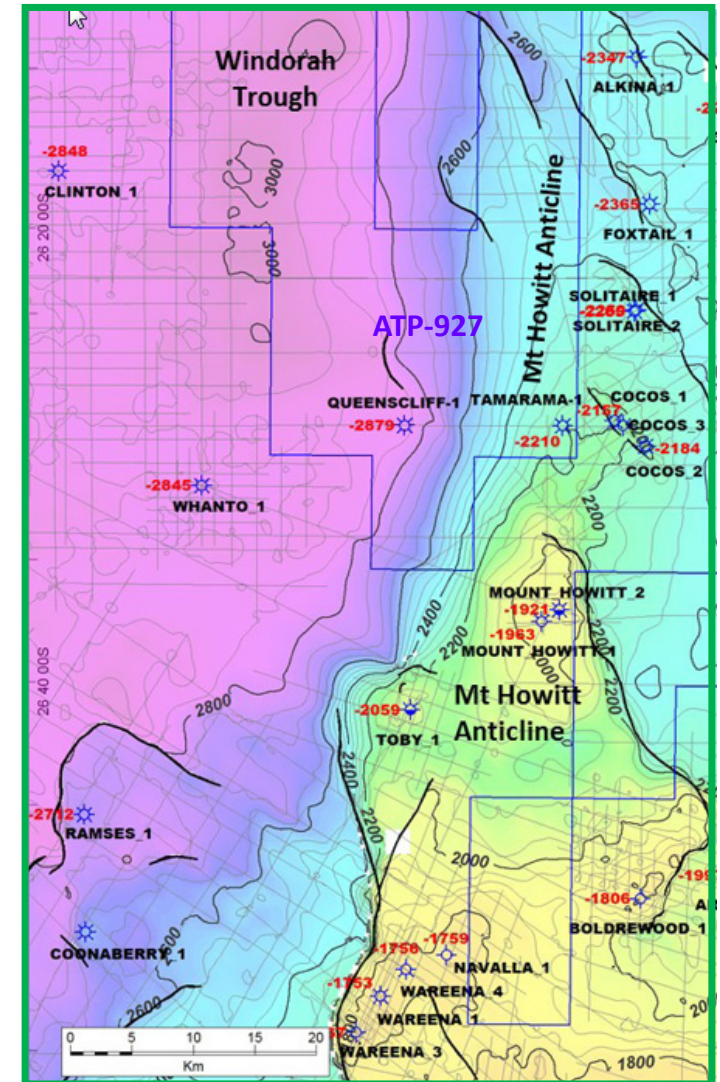
- ATP 927 overlies the eastern Windorah Trough and western flank of the north-plunging Mt Howitt anticline
- The Windorah Trough and Mt Howitt anticline date to Palaeogene east–west compression that reactivated and inverted many older Cooper Basin structures
- A structural high trend with a number of low relief culminations lies immediately to the west of ATP 927
- Gas discoveries have been made along the deep structural trend and on the Mt Howitt anticline





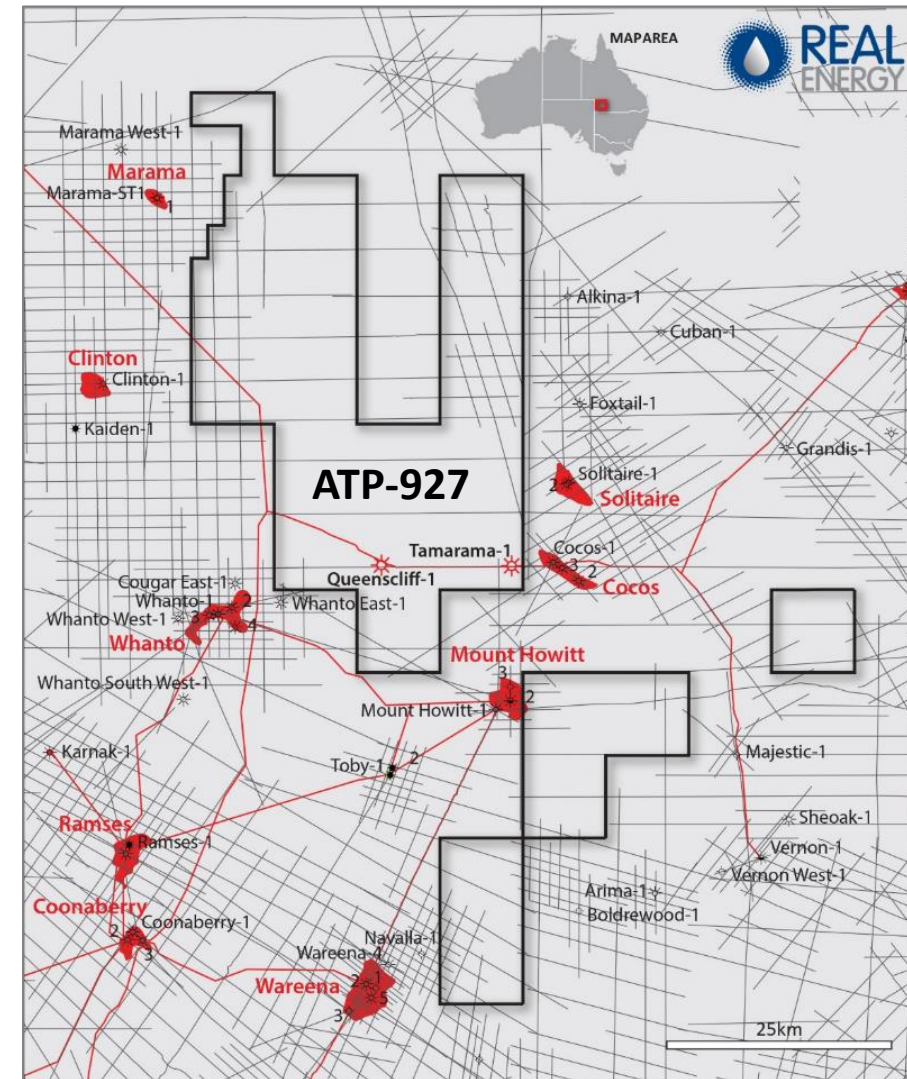
# Windorah Trough Reservoirs

- Historic wells characterised the Toolachee and Patchawarra formations as being gas-charged, tight-gas, sandstone/lacustrine shale sequences having layers of coaly source rock with high total organic content and moderate hydrocarbon indices
- Pressure build-up surveys indicate reservoirs are slightly over-pressured and area drill stem tests have mostly either failed to produce gas or resulted in non-commercial flow rates, substantiating 'tight-gas' potential
- Encouraging gas shows at Real Energy's Tamarama 1 and Queenscliff 1 following underbalanced perforating forebode well for post-stimulation rates



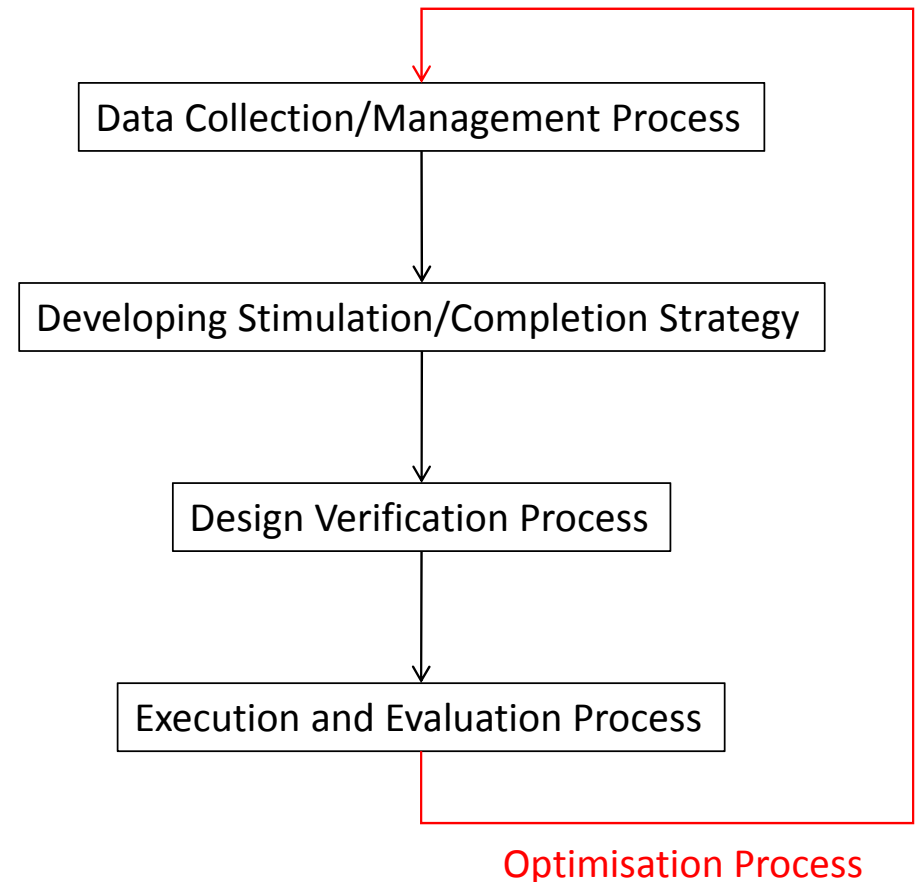
# Windorah Trough, a Basin Centred Gas Play

- All unconventional reservoirs require optimal go-forward extractive technology to establish an economic development plan
- Vertical, hydraulic fractured wells are successful in North America's normal stress regimes for tight gas
- Basin-centred gas play success has been slower to develop in the compressive and transpressional stress regimes forming many basins outside North America, including the Cooper Basin
- Real Energy embarked on a methodical approach to define the stimulation strategies and long term well designs to unlock this pervasive resource



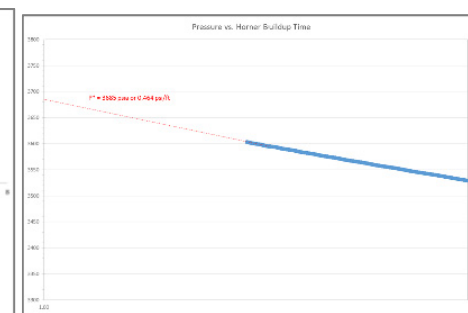
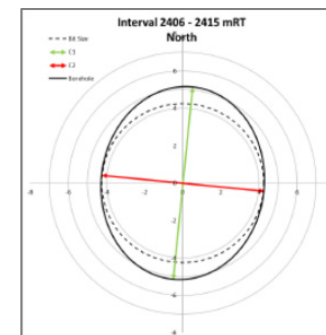
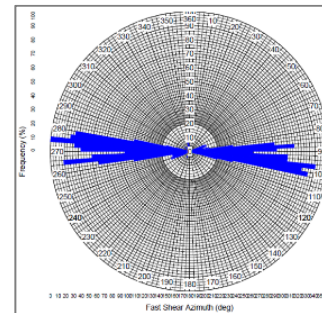
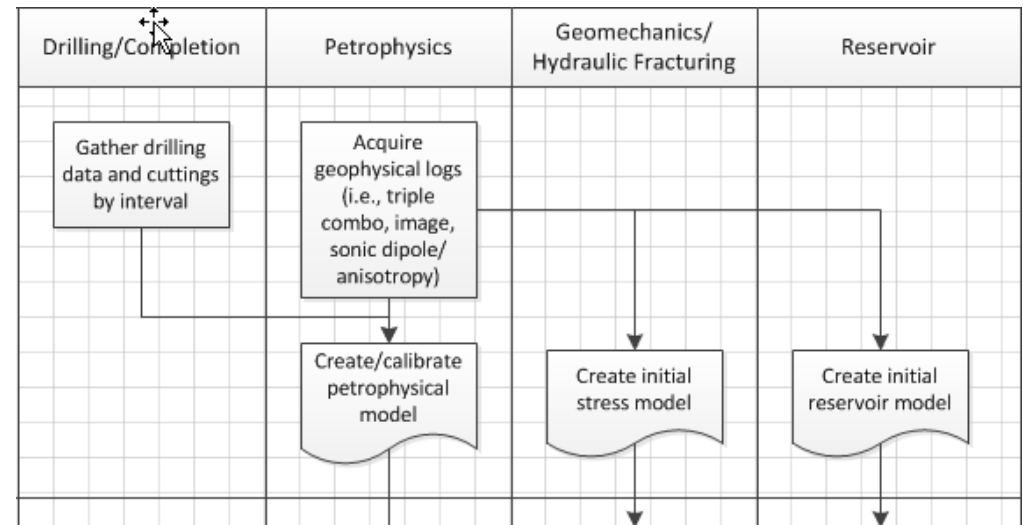
# Design Optimisation Process

- “Tight-gas” development strategies are primarily hinged on hydraulic fracturing success
- Many of the processes used today are evolutionary processes of the Gas Research Institute (GRI) Advanced Stimulation Technology (AST) research that culminated after two decades of experimentation in North America in the late-1990’s
- Unfortunately, many of these strategies are largely predicated on a normal stress regime and have not had universal translation beyond North America



# Data Collection/Management Process

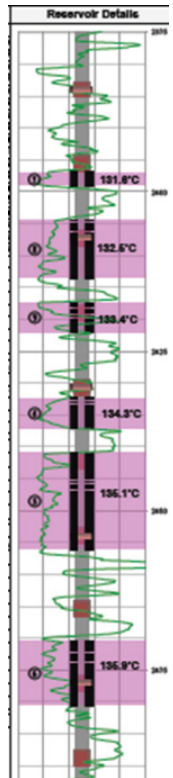
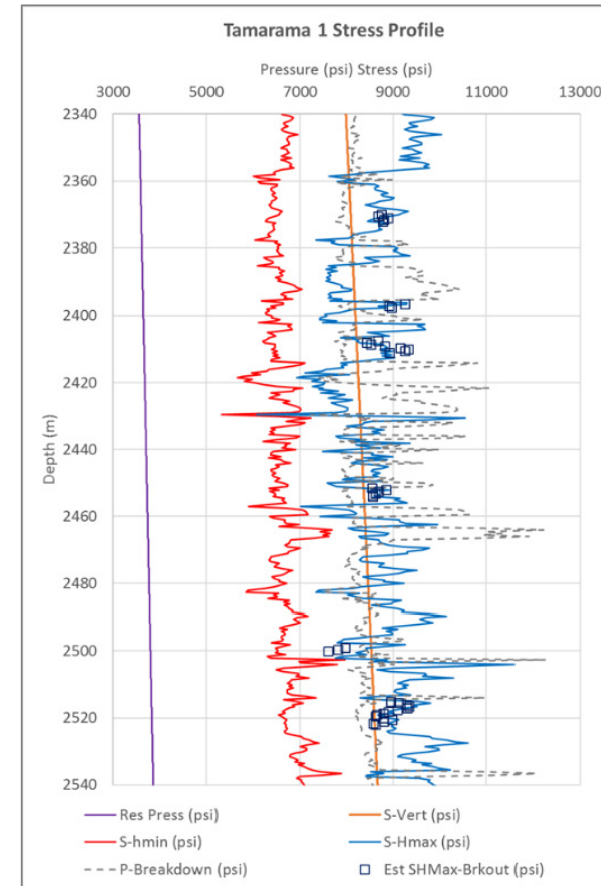
- Real Energy realised this and set out on a thorough data collection and evaluation process to develop a design strategy for two existing wells, Tamarama 1 and Queenscliff 1
- Log data were acquired to determine rock mechanical properties, stress azimuths/magnitudes, estimate permeability/porosity, and high-grade target intervals
- Cuttings were acquired to rock type target intervals for permeability/porosity models
- Initial stress profile was estimated based on breakout and regional data and pressure buildup data indicating slight overpressure





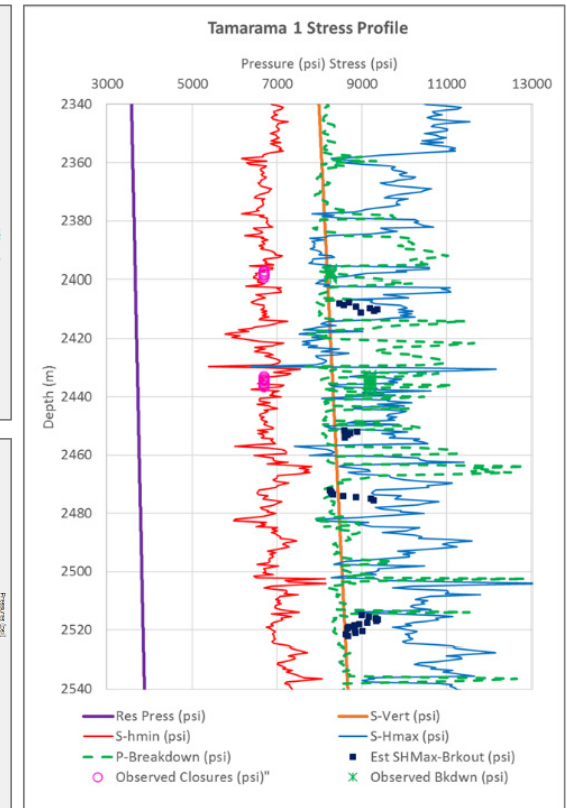
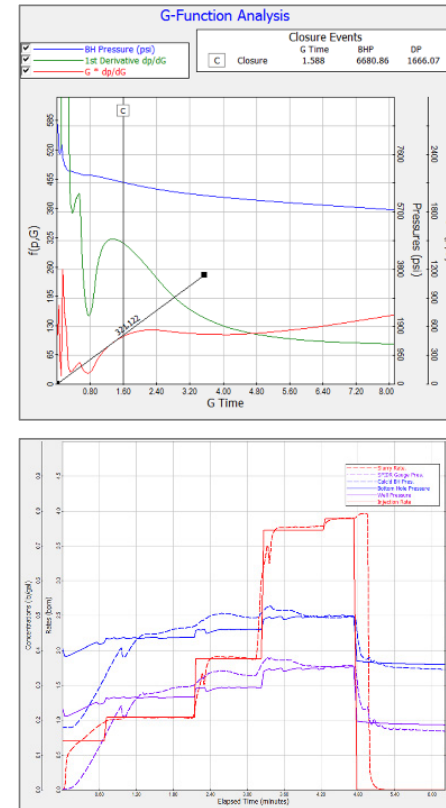
# Developing Stimulation/Completion Strategy

- Initial stress profile, petrophysics and rock-typing were used to develop completion strategy and determine intervals for diagnostic fracture injection testing (DFIT)
- Zones were isolated by an inside casing, tubing deployed, swell packer with frac sleeve, isolation system to achieve full coverage of all target intervals in five (5) stages.
- This completion strategy allowed better treatment targeting akin to a 'pinpoint' frac system being deployed in a casing system, which has been successful in other Cooper Basin areas



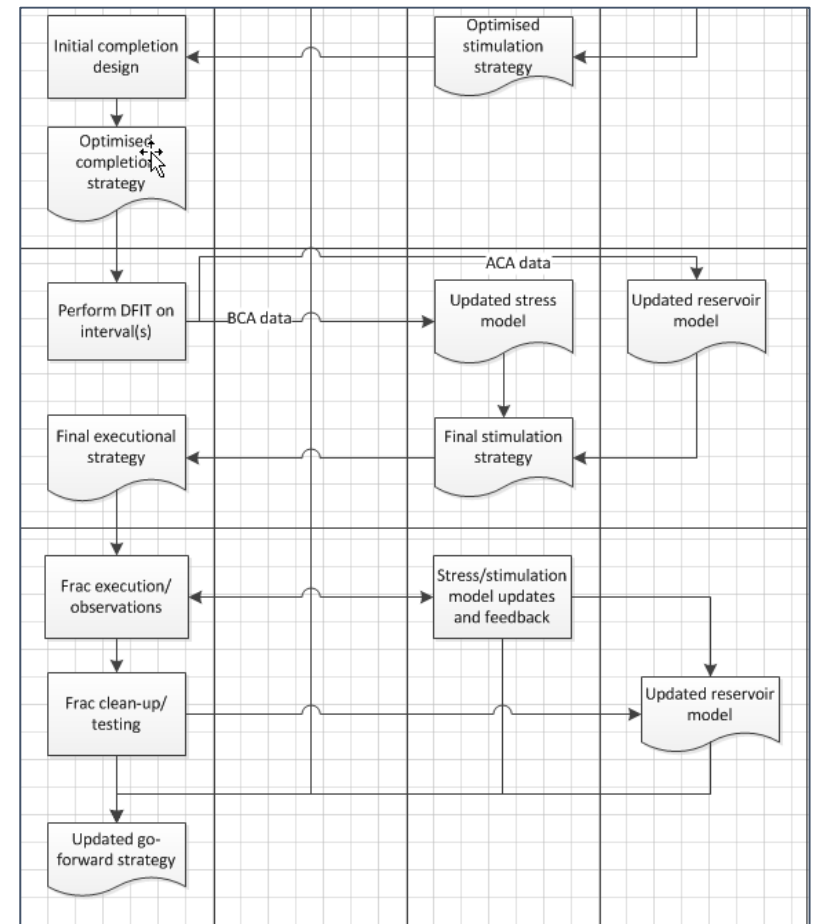
# Design Verification Process

- Prior to positioning the completion string for the frac, DFIT data was acquired in two (2) key Patchawarra and Toolachee intervals
- Ideally a shale interval, preferably in the rat hole section, would also be included for DFIT if a rigless completion were being used. By testing multiple intervals with varying modulus values we can further constrain  $\sigma_{HMax}$  by history matching to strains in  $\sigma_{hmin}$  and  $\sigma_{HMax}$  directions, using breakdown and closure pressures (Polakai, et al., APPEA, 2016)
- DFIT injections were pressure history-matched to determine process-stress magnitudes and estimate near wellbore pressure loss (NWBPL) and pressure dependent leakoff (PDL) values, not uncommon in the Cooper Basin due to high deviatoric stresses and natural fracturing (Johnson and Greenstreet, SPE 84492, 2006 and Johnson et al., APPEA, 2015)



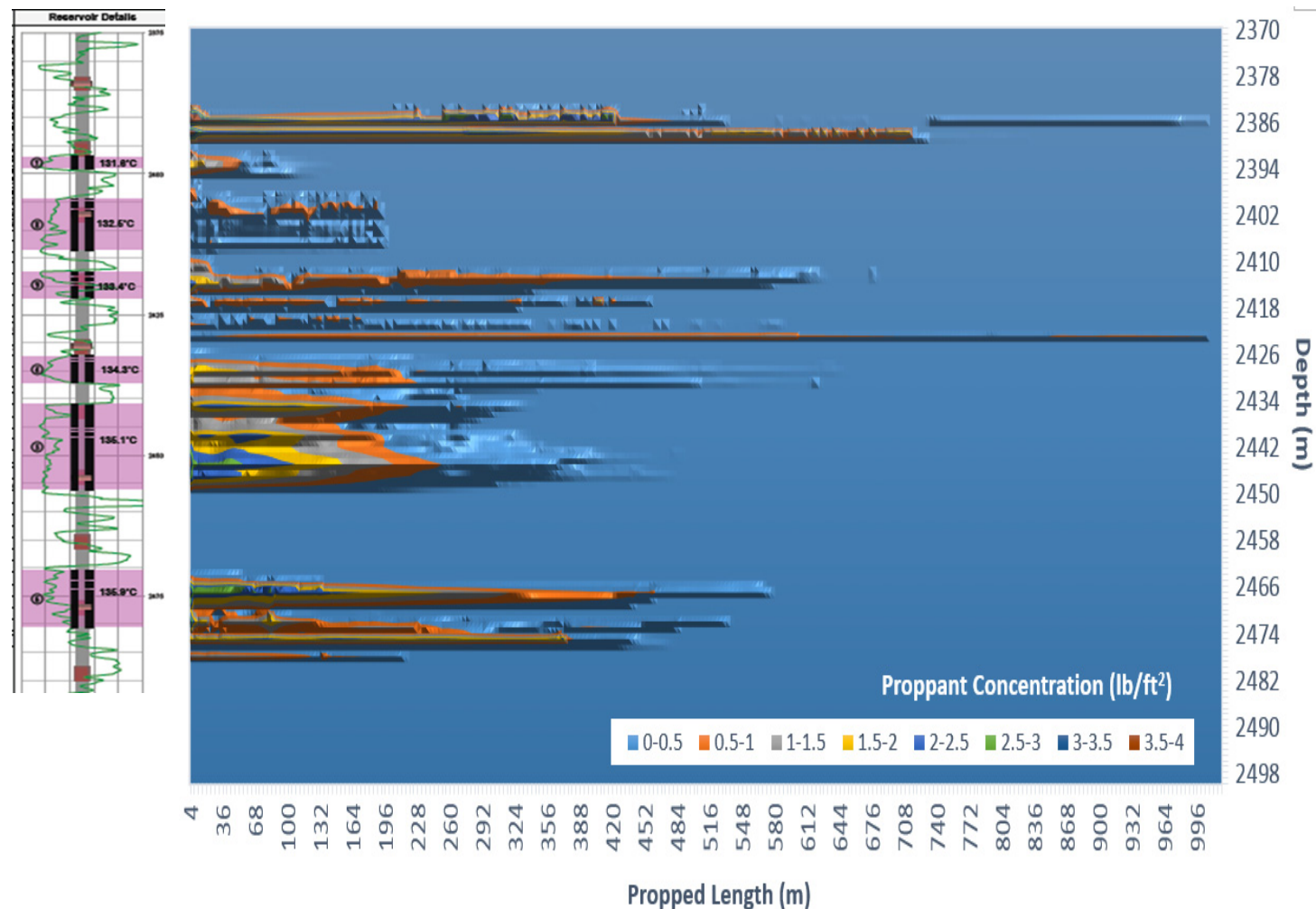
# Execution and Evaluation Process

- After verifying the stress and frac models with the DFIT data, the completion string was positioned for the frac, and a DFIT and mini-frac (e.g., gelled water injection test, gelled water step-up/step-down test) were planned in the first Patchawarra interval to verify the model
- The process would then consider pre-frac DFIT or mini-frac injection data from each stage to fine tune the stress, permeability and hydraulic fracturing parameters to improve subsequent execution and previous stage interpretation
- The estimates of permeability from DFIT and mini-fracs can provide better estimates of relative permeability to gas based on history matching of production using post-frac dimensions from frac treatment pressure history-matching
- This essentially follows the steps of the GRI AST deployment strategy with key elements adapted to better design and execute frac treatments in Australia's complex stress regimes, the total workflow is detailed in the extended abstract



# Recent Activity

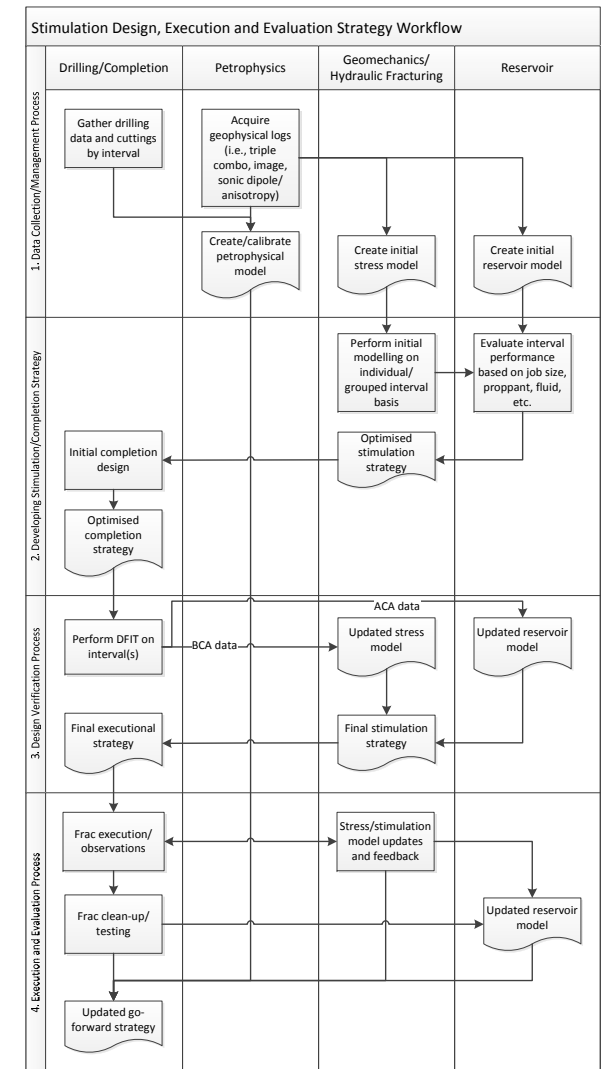
- Five (5) frac stages were effectively placed in the Patchawarra and Toolachee Fms in Tamarama 1
  - 342,000 gallons of gelled and crosslinked gelled water
  - 433,000 pounds off proppant (predominantly 20/40 medium strength ceramic)
- Well is currently flowing back fluid and will be tested following clean-up





# Go Forward Strategy

- History-match production using post-frac dimensions from frac treatment pressure history-matching and production logging data
- Revisit the process workflow for go-forward well stimulation strategies including:
  - Detailed evaluation of image log and stress regime (1D stress model) based on additional closure data from pre-frac DFIT and DFIT/mini-frac closure data acquired in each isolated interval
  - Evaluate natural fracturing azimuth and bedding plane geometries relative to 1D stress model
  - Review onsite pressures and modelling results to optimise well mechanical configuration to manage frac execution
  - Consider potential diagnostic plan to reduce design uncertainties
- History-match production using post-frac dimensions from frac treatment pressure history-matching and production logging data
- Prepare optimised well strategy for pilot testing based on revised workflow to minimise NWBPL and maximise natural fracture interaction(e.g., well azimuth, inclination, perforating strategy, etc.)



# Summary

- Real Energy has identified a 'basin centred' gas play in the Windorah Trough of the Cooper Basin and has begun the process of developing a coupled well design and stimulation strategy to prove commerciality
- A execution and evaluation strategy was implemented to incrementally obtain reservoir data to optimise a hydraulic fracture design
- Five frac stages were placed in Tamarama 1 with good coverage over all targeted Toolachee and Patchawarra intervals
- Data successfully gathered during drilling, DFIT and fracture stimulation treatments will enable Real Energy to optimise future well designs and stimulation strategies

# Thank you!

The authors would like to recognise and acknowledge Real Energy and Unconventional Reservoir Solutions for their support and resources in preparing this presentation

