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Marginal and Mature Field Development and Operation

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Fit for Purpose Completions for Marginal Projects with Sand Control Requirements

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Problem Statement and Root Causes

Poor infill project economics for marginal and mature fields especially reservoirs that technically require downhole sand control

Marginal Reserves
0.5 - 0.7 MMSTB / Well

Conservative oil price estimates due to uncertainties
Cautious since 2015 slump and 2020 COVID

High CAPEX especially for Well Cost
Driven by more complicated well design e.g Fracpack
Escalation in raw material and services prices

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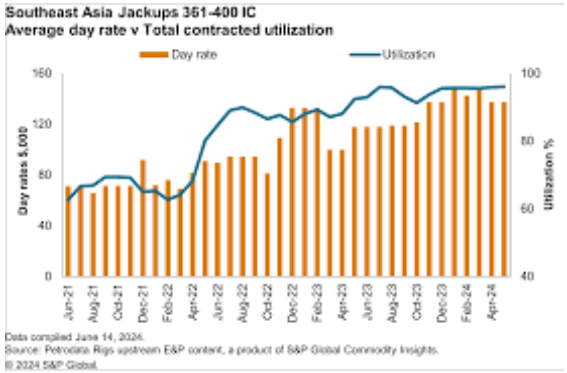
Well Cost is Becoming More Expensive in Brownfields

Escalation of Rig Rate
Since 2022



Price Escalation of Tangible & Services
Driven by geopolitical and market impacts

More Complicated Well Design for Brownfields
Complex sand control operations – e.g Fracpack

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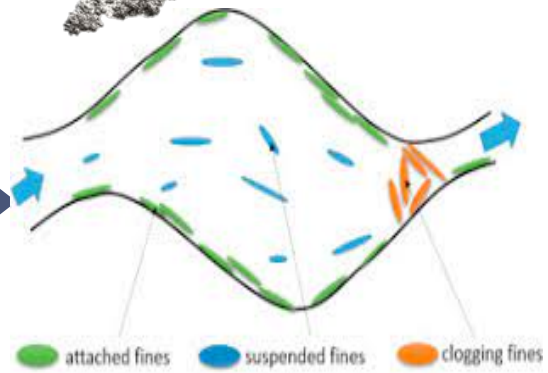
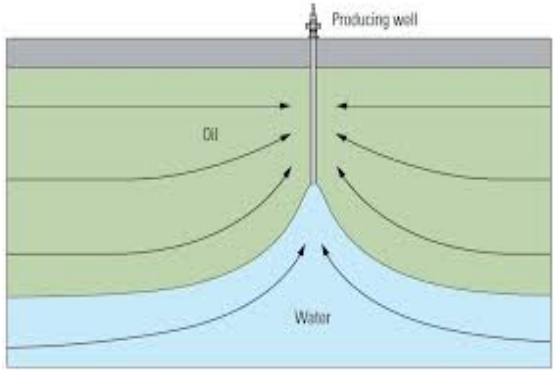
Sand Makes Things Complicated!

Very unconsolidated sand
UCS < 1,000 psi
Shallow & depleted reservoirs

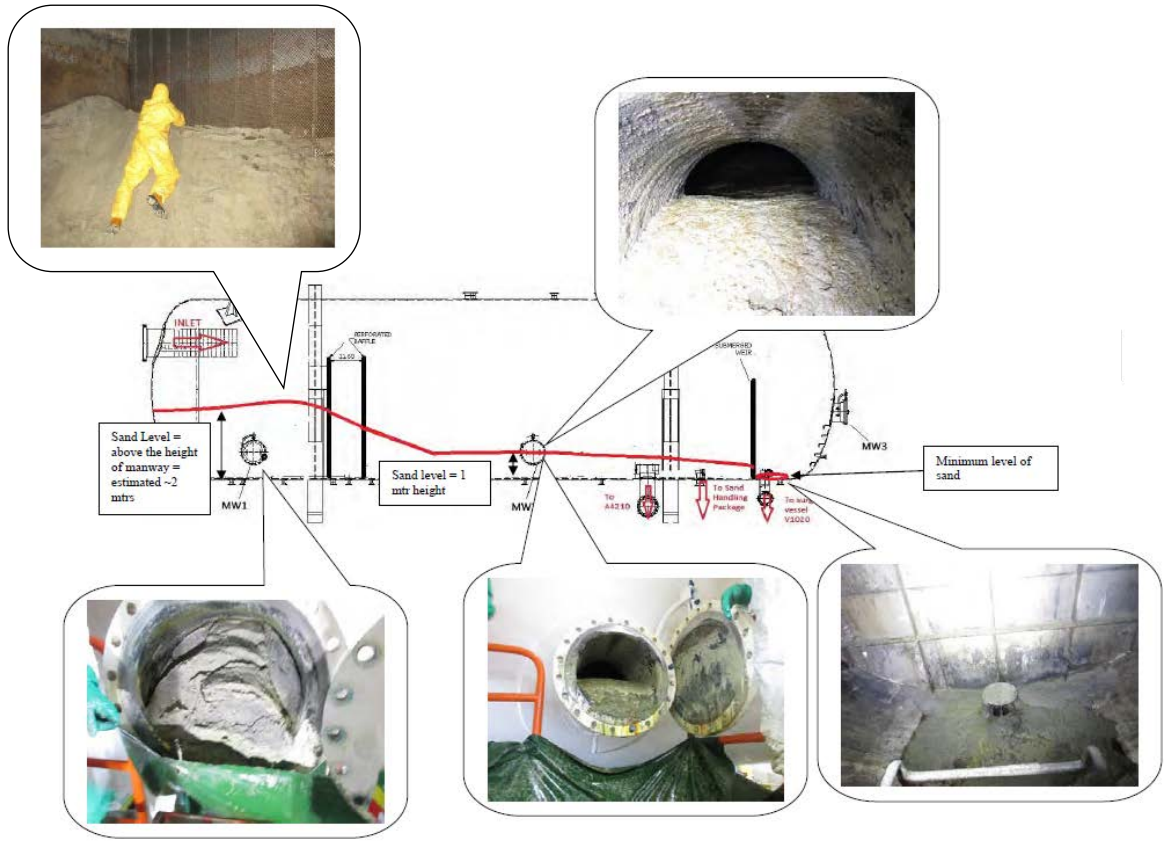
High fines content
Exceeding 20% and in some cases reaching 50%



Water breakthrough
Further weaken the rock by 30% – 70%
UCS < 500 psi



Sand Makes Things Complicated!



LP Separator sand removal

- Total of 379 Drums of sand sludge recovered during vessel cleaning in Apr 2022 TA (Duration of 21days)

Choke Erosion

Control Valves Damaged

Strainer Erosion

Tubing leak
Joint leak
HUD
Pump Damage/Vibration
And many More!

Pipeline pigging operation

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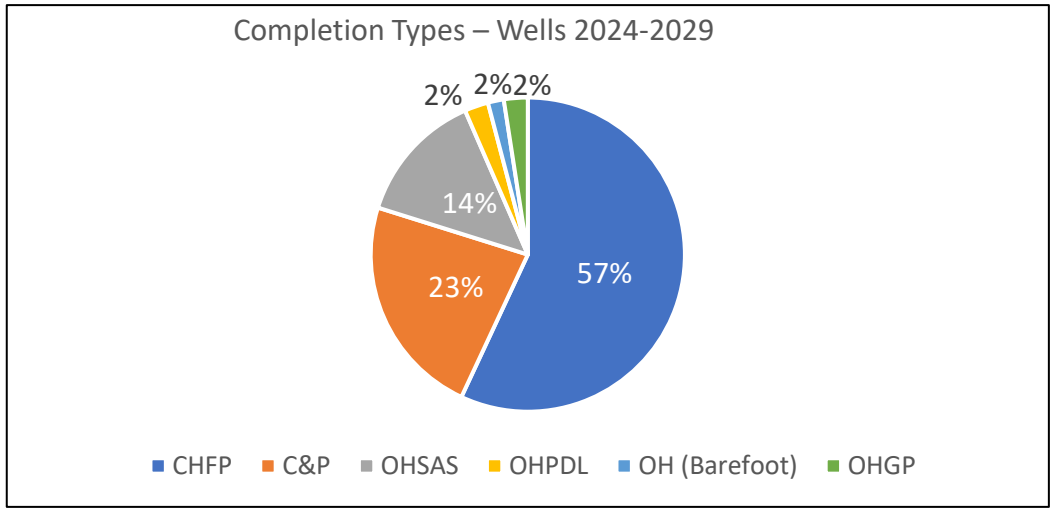
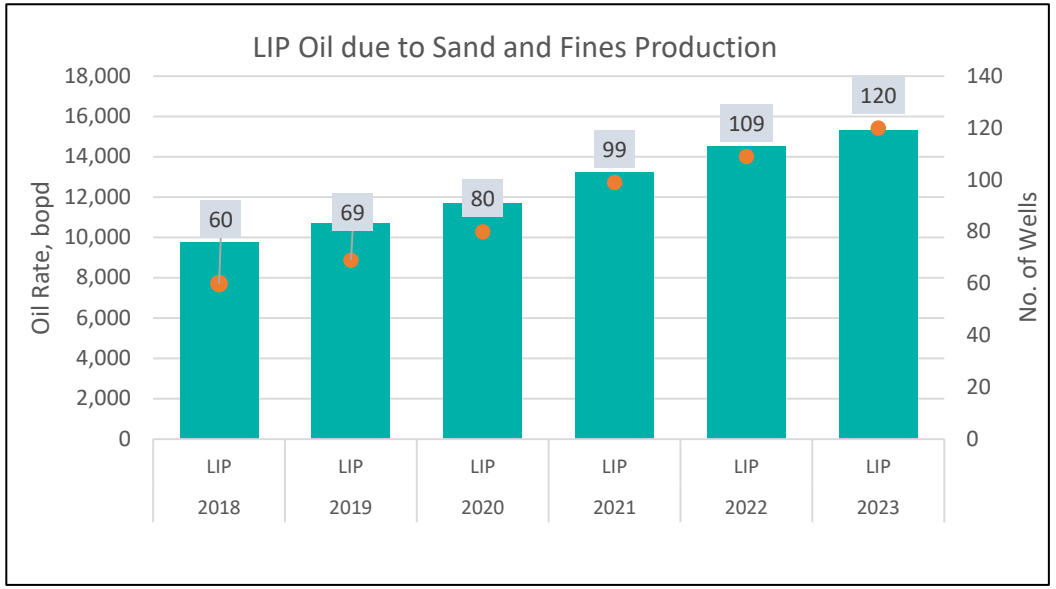
Well Outlook for the Next Five Years

- **73%** of Malaysia development wells in the next 5 years will **technically require sand control** – majority in matured brownfields
- 23% of cased and perforated wells are either water injector, gas injector or high-rate gas wells
- **Locked-in Potentials (LIP)** due to sand production issues is increasing exponentially
- Multizone Single Trip Fracpack (MZST FP) has been a successful method since 2020 however recent well **cost escalation affects project economics**.



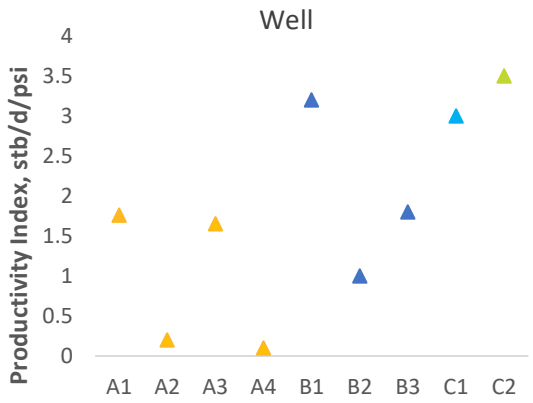


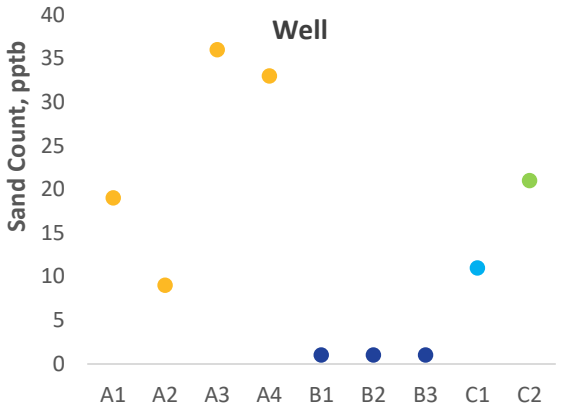
Fracpacking Solves the Problem

Embarked on fracpacking campaigns since 2020

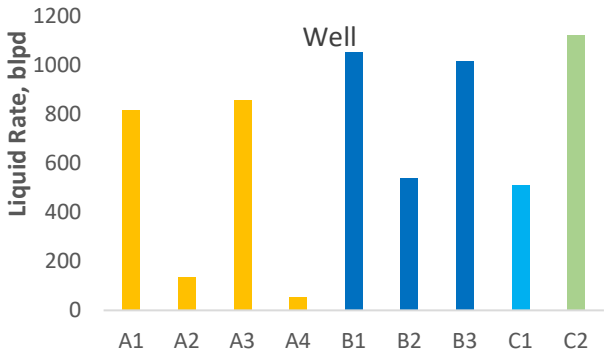
Observed PI : **1.0-3.5** stb/d/psi

Good Sand Count : **<30** pptb





Field D 2020 Frac Pack
Field B 2020 Frac Pack
Field D 2022 Frac Pack
Field D 2022 Screenless Frac Pack



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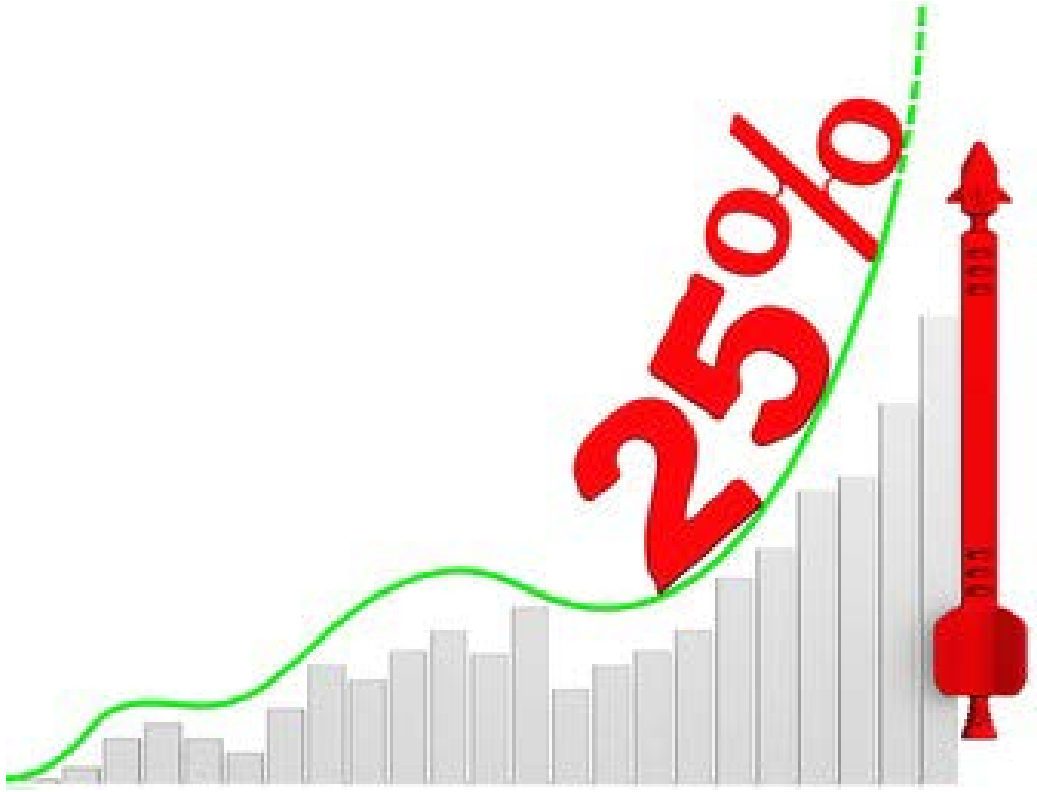
Fracpacking Marginal Brownfield Wells is Economically Unsustainable



- USD 3-4 MM per well to perform multizone single trip fracpack. Roughly 25% to 30% of total well's cost.
- Many unsanctioned projects

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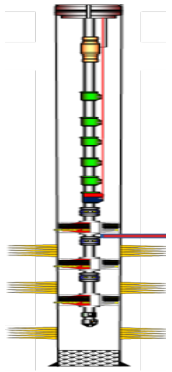
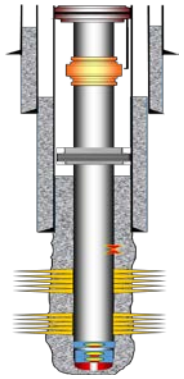
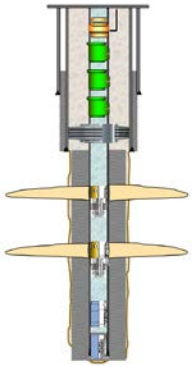
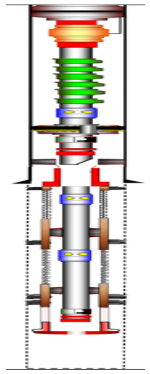
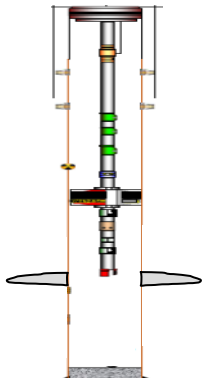
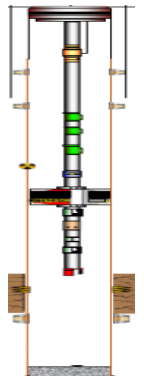
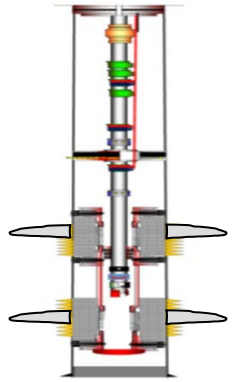
Fit for Purpose Completions – Way Forward!

	1. C&P-ER-TTSS	2. Cemented Monobore-ER-TTSS	3. Cemented Monobore Frac Sleeve Screenless FP	4. Cemented Monobore - Resin	5. Open Hole Stand Alone Screens (OHSAS)	6. C&P - Screenless FP	7. C&P Resin	8. Single Trip Multizone STMZ System - FP/HRWP
								
Infill Well Cost :	USD X+1 MM (3 Zones)	USD X MM (3 Zones)	USD X+2 MM (3 Zones)	USD X+2 MM (3 Zones)	USD X+2 MM (300m OHSAS)	USD X+2 MM (1 Zone-FP)	USD X+5 MM (3 Zones)	USD X+5 MM (3 Zones-FP)
Completion Cost :	USD Y+1 MM	USD Y MM	USD Y+1 MM	USD Y+1 MM	USD Y+2 MM	USD Y+2 MM	USD Y+4 MM	USD Y+4 MM
Criteria Economic Life :	< 10 Years	< 10 Years	< 15 Years	< 10 Years	< 15 Years	< 15 Years	< 10 Years	< 20 Years
Transport Sand to Surface :	Yes	Yes	No	No	No	No	No	No
Fines Content :	Irrelevant but must transport to surface	Irrelevant but must transport to surface	>15%	Irrelevant	< 15%	>15%	Irrelevant	> 15%
Additional Surface Sand Management :	Desander/ Sand Cleanup / Acoustic Sand Monitoring	Desander/ Sand Cleanup / Acoustic Sand Monitoring	Optional	Optional	Optional	Optional	Optional	Optional
OWC/GOC :	Irrelevant	Irrelevant	> 20 ft	Irrelevant	Irrelevant	>20 ft	Irrelevant	Irrelevant
Selectivity :	Yes	Yes with cost	Yes with cost	Yes with cost	Yes	Single zone only	Yes	Yes
Gas Lift Depth Limitation :	Optimized	Potentially unoptimized due to shallower TOC	Potentially unoptimized due to shallower TOC	Potentially unoptimized due to shallower TOC	Optimized	Optimized	Optimized	Optimized
TTSS for Primary Sand Control:	Yes	Yes	No	No	No	No	No	No
Selective Perforation :	Yes	Yes	N/A	N/A	N/A	N/A	N/A	N/A

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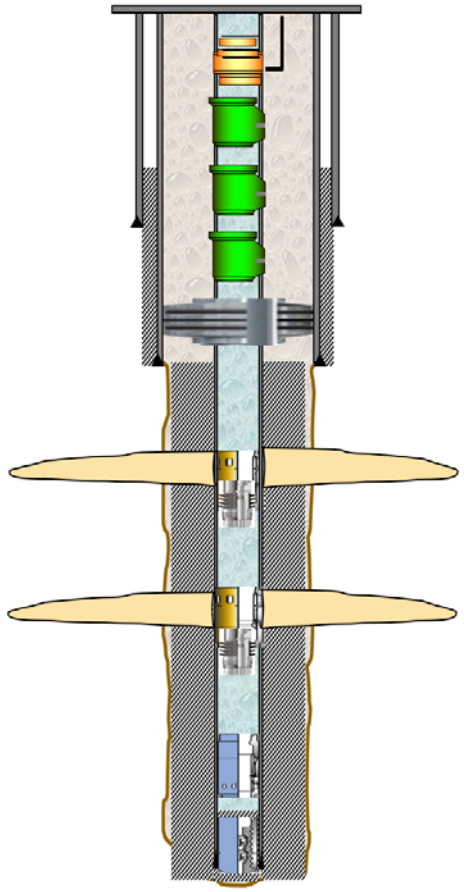
Cemented Monobore with Frac Sleeves - Fracpack



- Pilot well for smart frac sleeves application in a conventional sand prone reservoir
- Performed laboratory tests on the dissolvable darts and yard test on the smart frac sleeves
- Performed proppant flowback studies (laboratory and simulator)
- Success in the first zone – bottom-most zone
- No sand production nor proppant flowback
- To be further matured in more wells based on previous lessons

Conclusions

- Cost escalation requires major shift in the way wells are designed and operated
- Philosophical change in brownfield development is inevitable
- Integration and collaboration between Wells, Petroleum Engineering and Asset is paramount
- Be bold, creative and persistent to strive for technical and commercial solutions