Sustainable Sand Management Control and Solutions - Balancing Performance, Costs, and Environment

20–21 AUGUST 2024 | KUALA LUMPUR, MALAYSIA

WELL INTEGRITY AND SAND CONTROL MANAGEMENT ON VERY SHALLOW PERFORATION WELL

M Nadrul Jamal, Pratika S Kurniawati

Pertamina Hulu Mahakam

OUTLINE

01 Background and Context

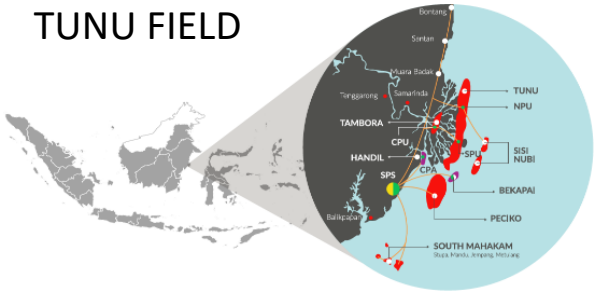
02 Well Integrity Management

03 Sand Control Management

04 Case and Result

VERY SHALLOW RESERVOIR

TUNU FIELD



1990 First Production

2000 Plateau production

2009 Tunu Shallow Development

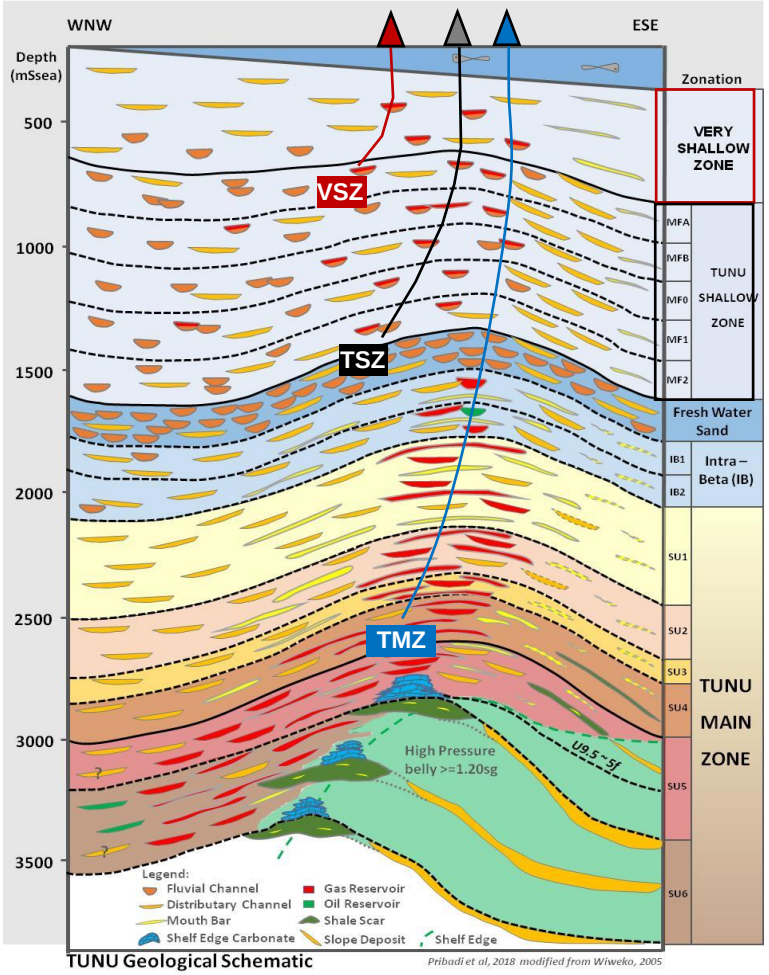
2019 Surface casing perforation

2022 Very Shallow Development

Above MFA
Shallow hazard
Near platform

Loose formation, Low FG
Small volume, low WH Pressure
Need Heavy workover or Twin well to evaluate
Require a lot of new WH platform

Existing well
New development

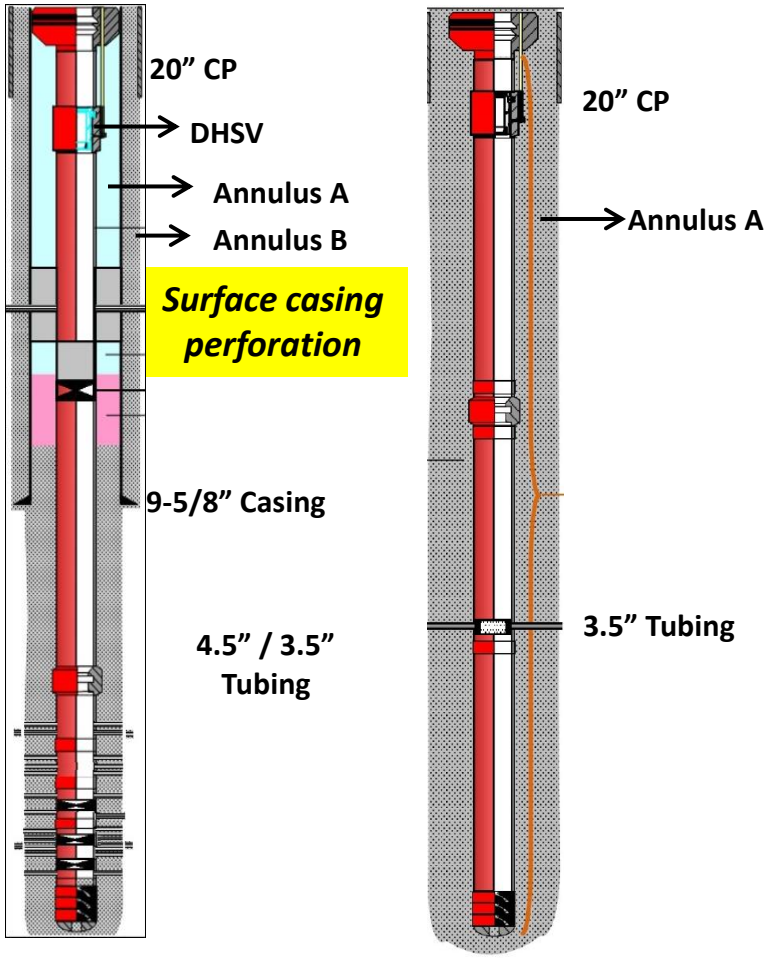


TUNU Geological Schematic

Pribadi et al, 2018 modified from Wiweko, 2005

OPERATIONAL CHALLENGES

Common Well Architecture for Very Shallow Candidate



1

Subsurface Aspect

a. **High cost of well intervention**: if requires cementing for Shallow Light Architecture and well with further well integrity investigation
b. **SCP shallower than 500 mSS**: safety issues related to fracture

3

Production Aspect

a. **Job Preparation:** Install bleed off line with PSV on annulus#B for SLA completion.
b. **Surface limitation.** PSHH setting
c. **Daily monitoring** from PO personnel minimum for the first week after put on production, Well Integrity Teamwill follow up if any abnormal condition

2

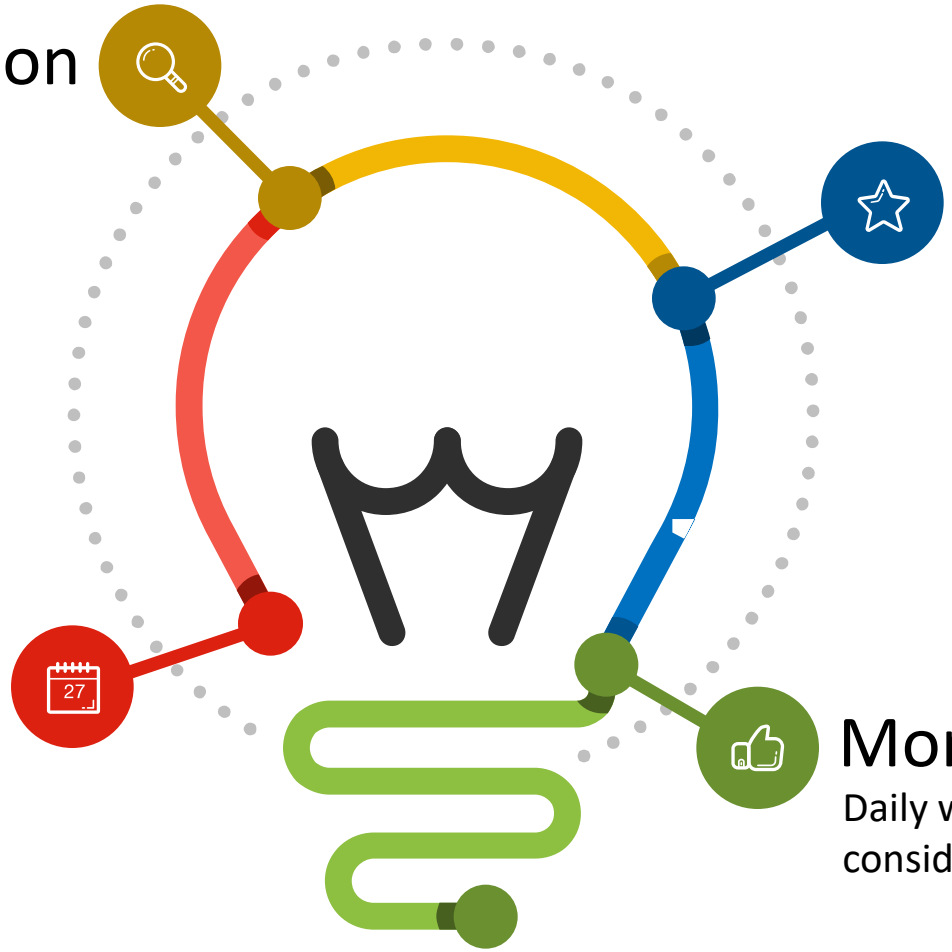
Well Intervention Aspect

a. **Job Risk Assesment**
b. **Presence of Sustain Casing Pressure:** to evaluate by integrity engineering review
c. **Pre-Perfo**
   - Cementing operation and cement quality review.
   - Annulus investigation (if found SCP)
   - SNL to found SCP source
d. **Post Perfo**
   - Pressure revolution post perforation

Specific Mitigation

Well Intervention

Validation of well barriers
Multi-purpose and well testing barge
Noise log prior and post perforation
Cement quality validated
Punch prior main perforation
Setting screen as sand control means



Production Operation

Bleed off line with PSV
Setting PSHH flowline
Mitigation to produce sand wells

Subsurface

Avoid ex-blowout area
Target reservoir vs shallowest perforation
Shale layer thickness

Monitoring

Daily well monitoring post perforation until consider stable

WELL INTEGRITY MANAGEMENT

1. Candidate Selection

Reservoir evaluation, Well Integrity review (shale, frac, cement), sand control, economic

2. Preparation

Well Integrity validation (leak rate, noise log), mitigation (Bleed off line, PSHH, choke, probe, Tee)

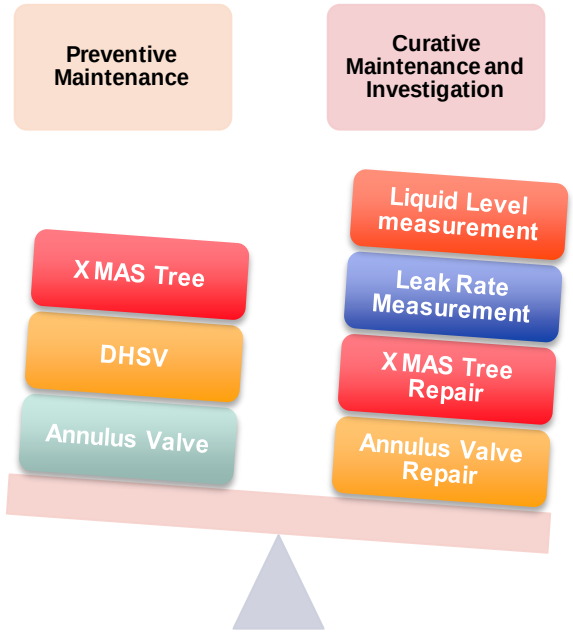
3. Operation

Testing standby, pumping unit, punch

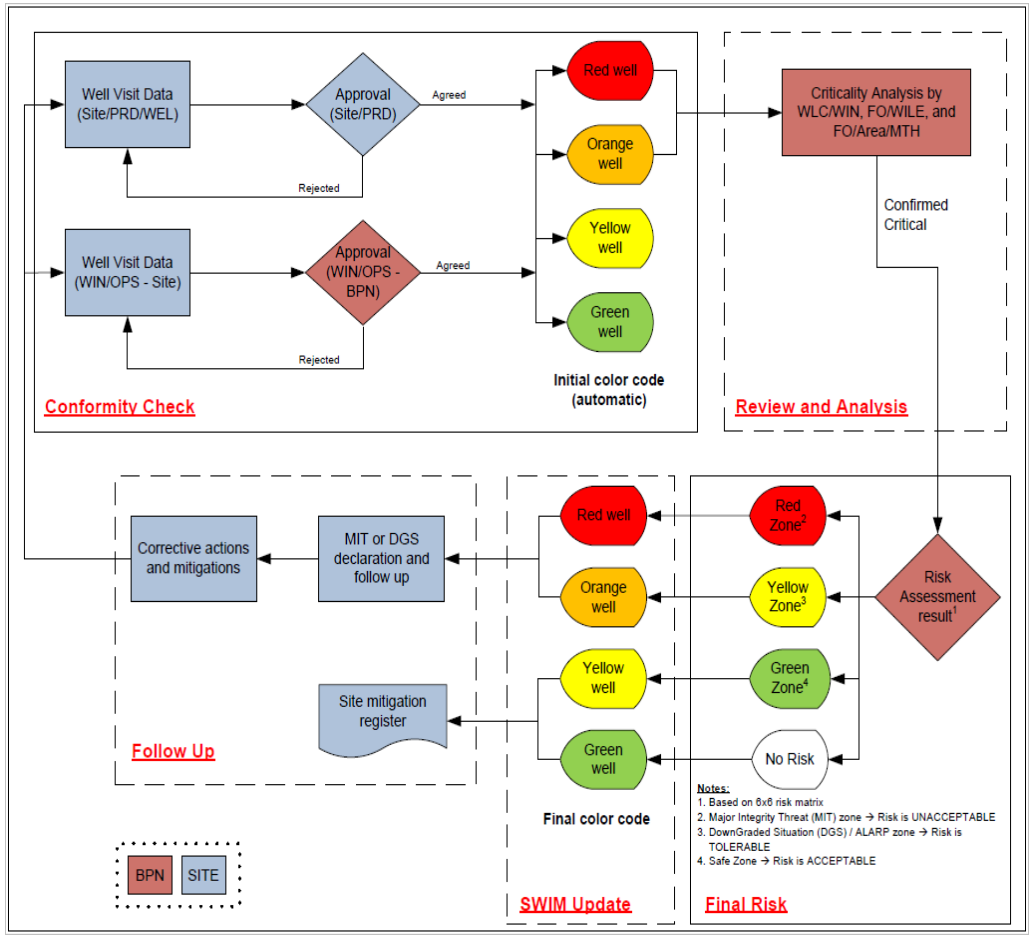
4. Monitoring

Production, Annulus monitoring

WELL INTEGRITY Management on Very Shallow Perforation Well Performed Throughout Operation Cycle



SMART WELL INTEGRITY MODULE (SWIM)



SWIM
Smart Well Integrity Module

The SWIM program has been used to record all the well integrity aspects for 2300++ wells within PHM perimeter.

The variability and combination of well locations and period of well installation have been becoming contributing factor to our extra effort for defining barrier element data. The summary are as follows:

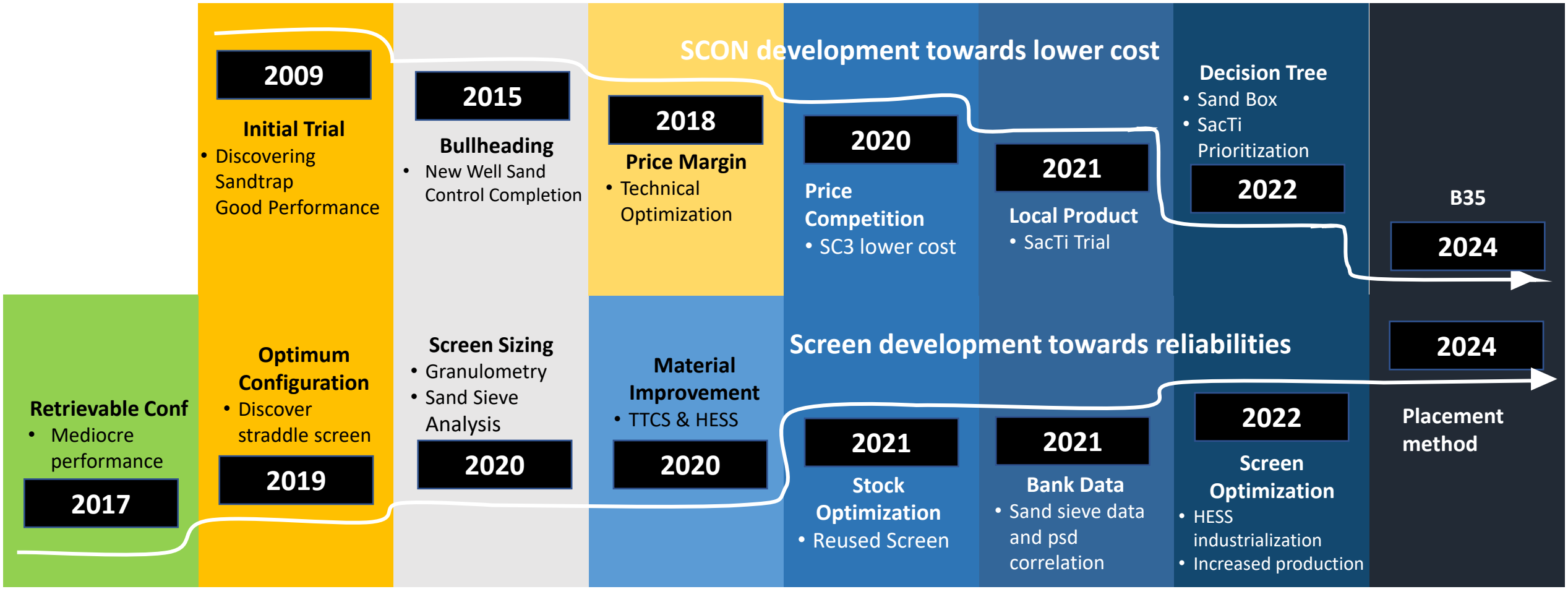
External Barrier with its combination of element identification.

Internal Barrier with its combination of element identification.

Color Code	Green	Yellow	Orange	Red
General Definition	Annulus Pressure, Internal and external well envelopes in good condition and no degradation	Annulus Pressure, Internal and external well envelopes in good condition but one or more aggravating factors exist with acceptable risk	One well envelope, internal or external, Annulus Pressure is failed. A single failure of a barrier may lead to leak to environment	Annulus Pressure, Internal and external well envelopes are failed or when leak is observed at surface

All monitoring activities has been managed thru digital platform SWIM (Smart Well Integrity Module)

SAND CONTROL MANAGEMENT



SCON MILESTONE

Cured resin sample

2018

SandTrap 225/350

HALLIBURTON

2019

Sandlock V

Schlumberger

Sandtrap ABC
Sandtrap 225/350

HALLIBURTON

2020

Sandlock V

Schlumberger

Sandtrap ABC
Sandtrap 225/350

HALLIBURTON

2021

SacTi-01

TITIAN

SC3 Furan

Baker Hughes

Sandtrap ABC
Sandtrap 225/350

HALLIBURTON

2022

Aquaset

Schlumberger

SacTi-01

TITIAN

SC3 Furan

Baker Hughes

Sandtrap ABC
Sandtrap 225/350

HALLIBURTON

2023

Trial

Bio-Scon

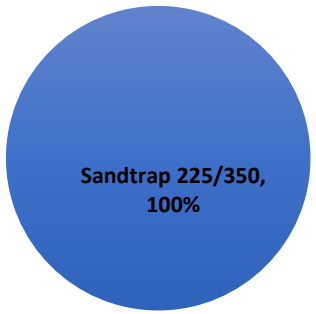
SRIJAN Caliche

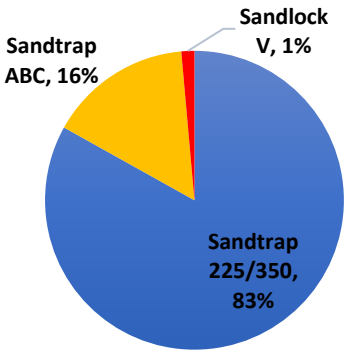
SacTi-01

TITIAN

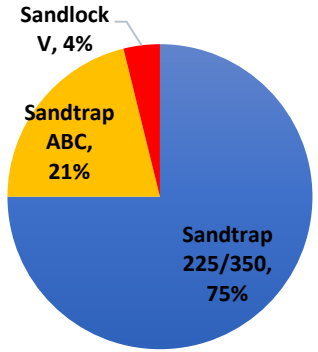
Sandtrap ABC
Sandtrap 225/350

HALLIBURTON

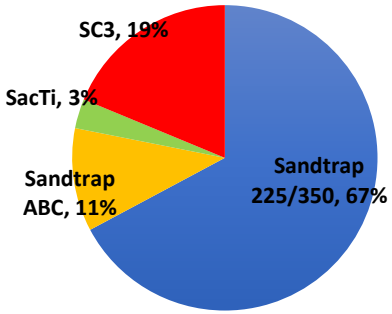




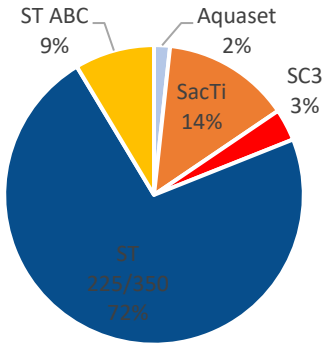
71 job



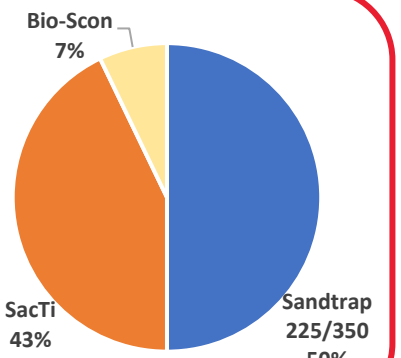
52 job



62 job



66 job

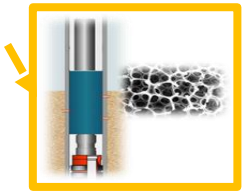


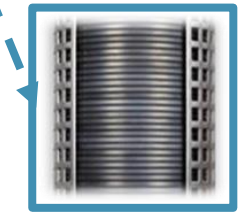
63 job

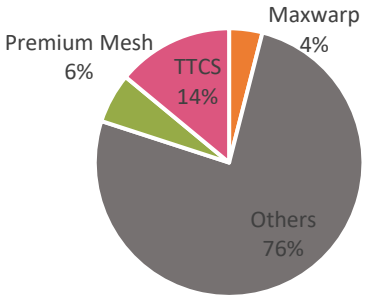
SCREEN MILESTONE

Sand Screen development and workload in Mahaka

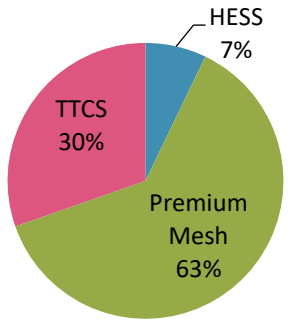
2020	2021	2022	2023
Others		Filtrex	Bead Screen
Wire Wrap	HESS	HESS	Multi weave
Premium Mesh	Premium Mesh	Premium Mesh	Boron
TTCS	TTCS	TTCS	Filtrex
			HESS
			Premium Mesh
			TTCS



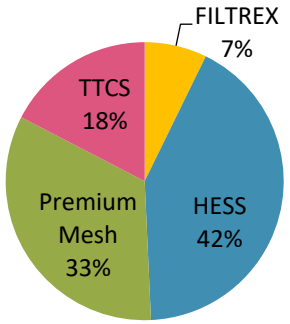




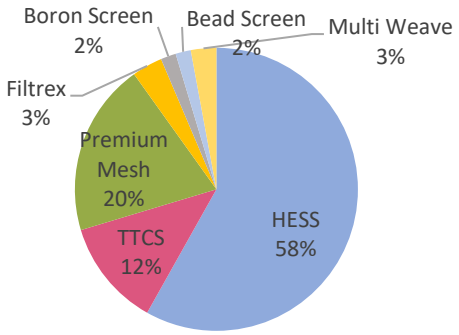
50 job



56 job



65 job

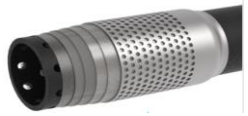


172 job

VSP SAND CONTROL: TT SCREEN

Sand Pass Thru

- Premium mesh screen no longer used in gas well.



☒ Premium mesh

☑ TTCS

☑ HESS

- Paragon packer used in high deviation well to ensure proper sealing.

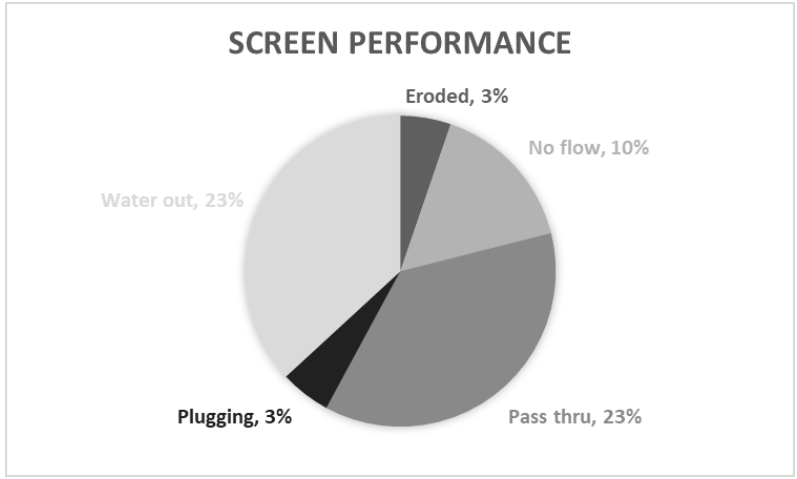
Plugging

- Replace with bigger opening size screen
- Change screen type (HESS screen never experienced plugging d/t its disc design)
- Careful ramp-up procedure

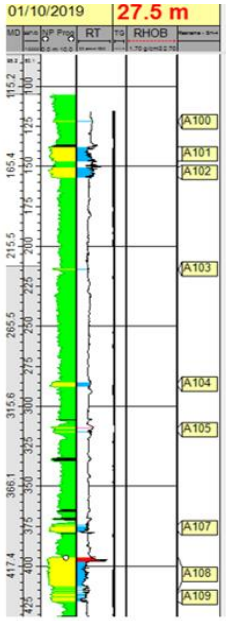
Well No Flow

- Potential test before set screen?

89.18%	Screen Installation Success Rate
62.16%	Screen Performance Success Rate
196%	Average Recovery Factor



VERY SHALLOW PERFORATION CASE

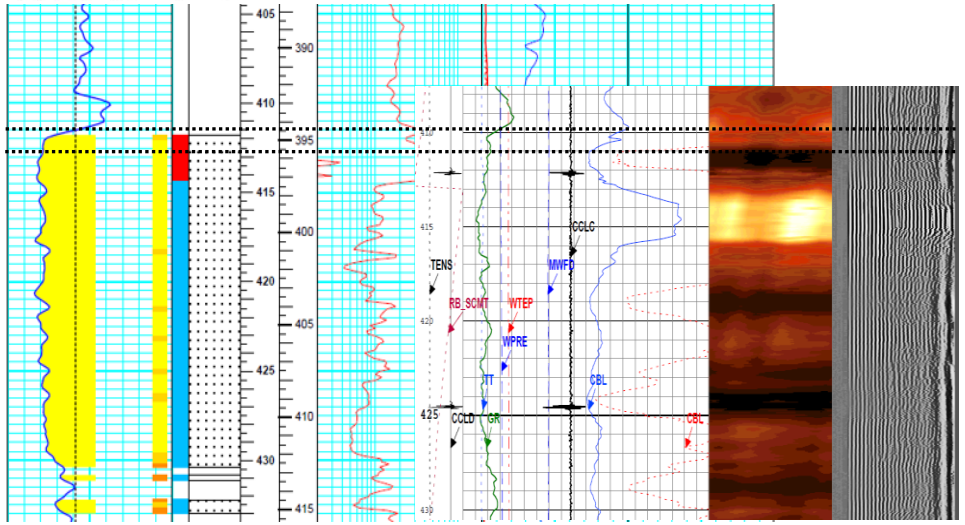


Total Shale = Thickness to Top Res – Thickness of Sand Reservoir – Thickness other Litho

Total Shale = 394m – 25.7m – 9.5 m = 358.8m

TOP	BOT	Litho	Thickness
151.486	152.857	Coal	1.371
323.698	324.46	Coal	0.762
347.777	350.063	Coal	2.286
380.543	382.067	Coal	1.524
386.029	389.077	Coal	3.048
395.63	396.088	Coal	0.458
			9.449

Well Name	Res Nar	Fluid	Top MD	Top TVI	Contact	Net Ab
TN-S182	A100	WATER	136.7	121.5204	WATER	0.75
TN-S182	A101	WATER	153.01	137.7517	WATER	9.12
TN-S182	A102	WATER	165.96	150.6606	WATER	6.23
TN-S182	A103	WATER	229.51	214.15	WATER	0.45
TN-S182	A104	WATER	300.23	284.8416	WATER	3.04
TN-S182	A105	GAS?	328.57	313.0515	G?WC	0.9
TN-S182	A105	WATER	331.17	315.6375	WATER	0.91
TN-S182	A107	WATER	390.3	373.8117	WATER	4.31



Res Name	Top Perfo (mMD)	Bottom Perfo (mMD)	Top Perfo (mSS)	Bottom Perfo (mSS)	Netpay ABC (m)	Contact	Avg Phi (%)	Avg Vsh (%)	Avg Perm (MD)	Pressure (psi)
AXXX	411.6	412.7	394.6	395.6	2.52	GWC	29%	26%	1550	576

Highlight prior perforation:

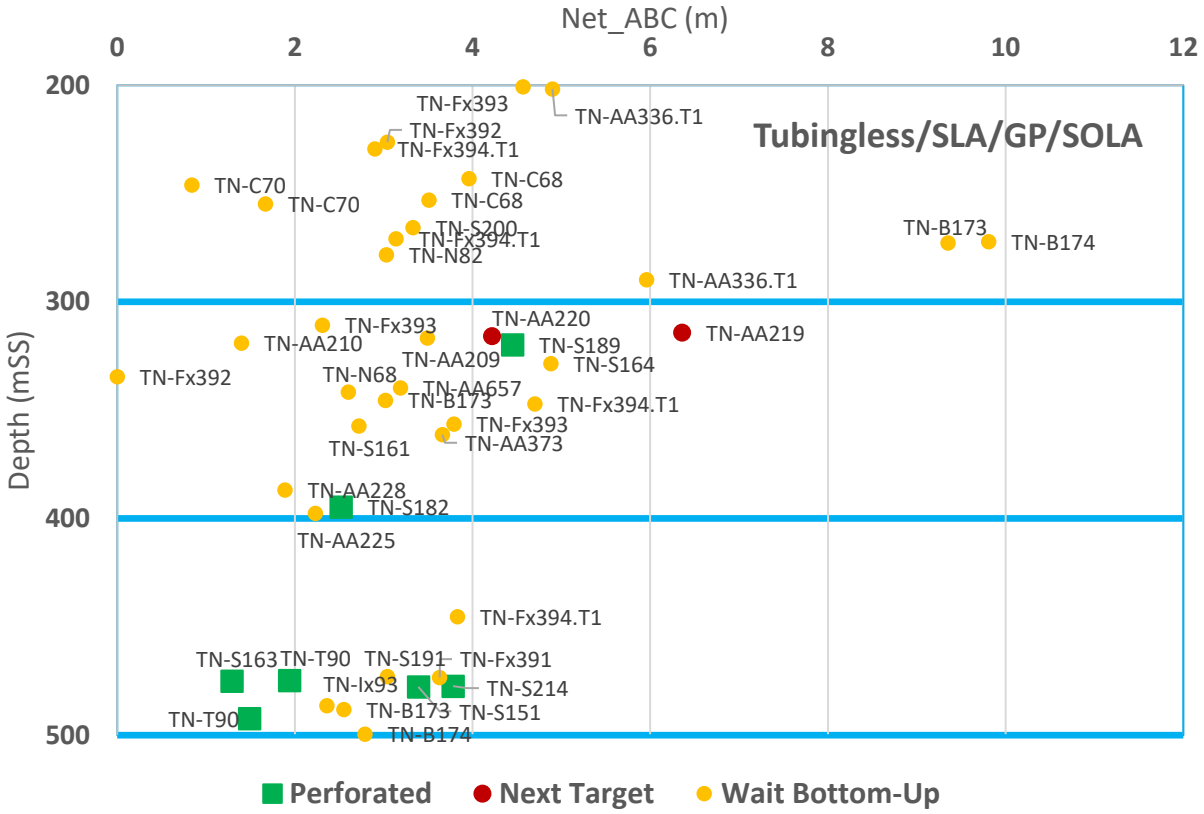
1. This well is SLA (consist of 2 Annulus), presence of Annulus pressure in Ann#B 6 – 7 Bar (MAWOP 15 B) with Leak Rate < 3 scfm.
2. Noise log result while venting Ann#B shows noise indication at 125 m and no connection to Res. A108.

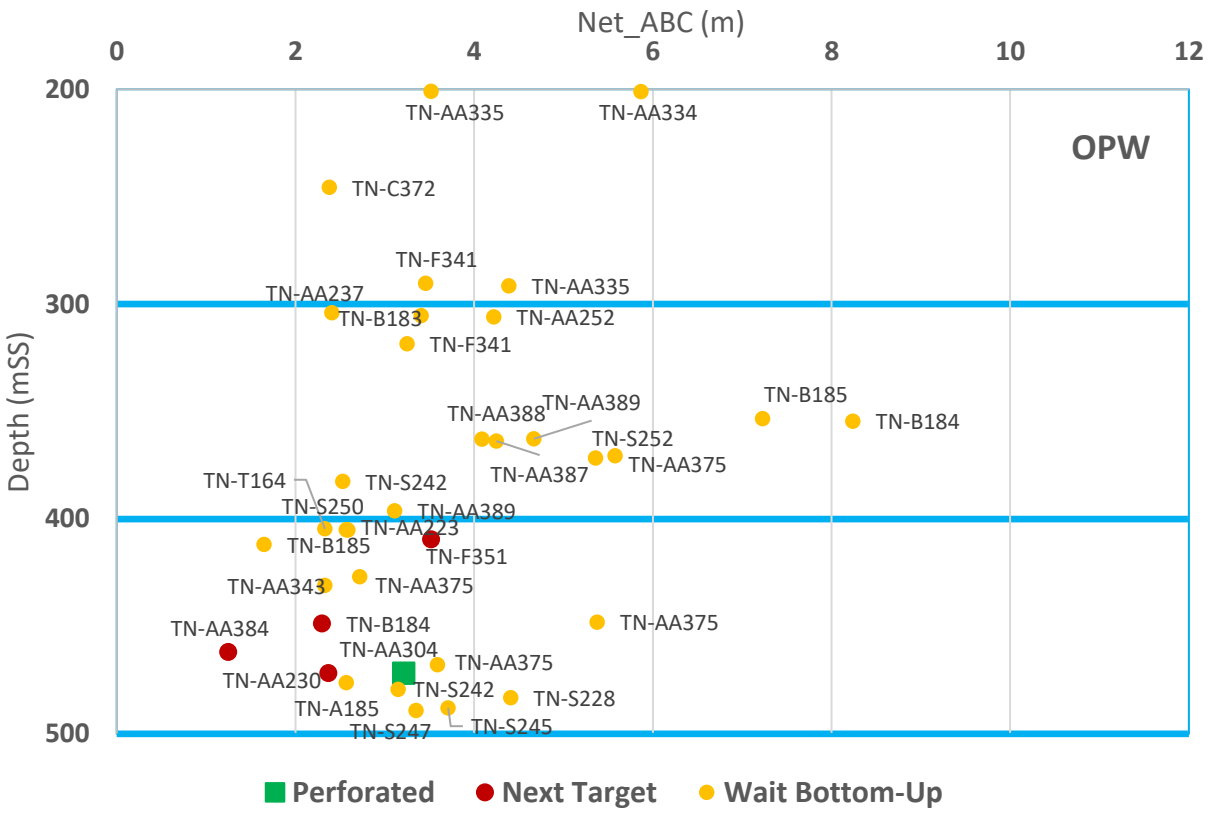
Result:

- Clean up result : Qg 1.1 MMscfd / 37.6 B, WHSIP 39.2 B

No increment of Ann#B pressure after perforation, indication of cement above perforation target to leak source are competence.

VERY SHALLOW PORTFOLIO





SUMMARY

- Very shallow reservoir is one of important play for Mahakam future
- Well Integrity and Sand Control Management are key for successful Very shallow development
- Trial have been done with promising result
- Very shallow portfolio shows more potential candidates yet more challenging environment

THANK YOU

ROADMAP TRIAL

2019

Discussion initiated for shallow perforation with Surface Casing Pressure, identifying risk of fracture

2022

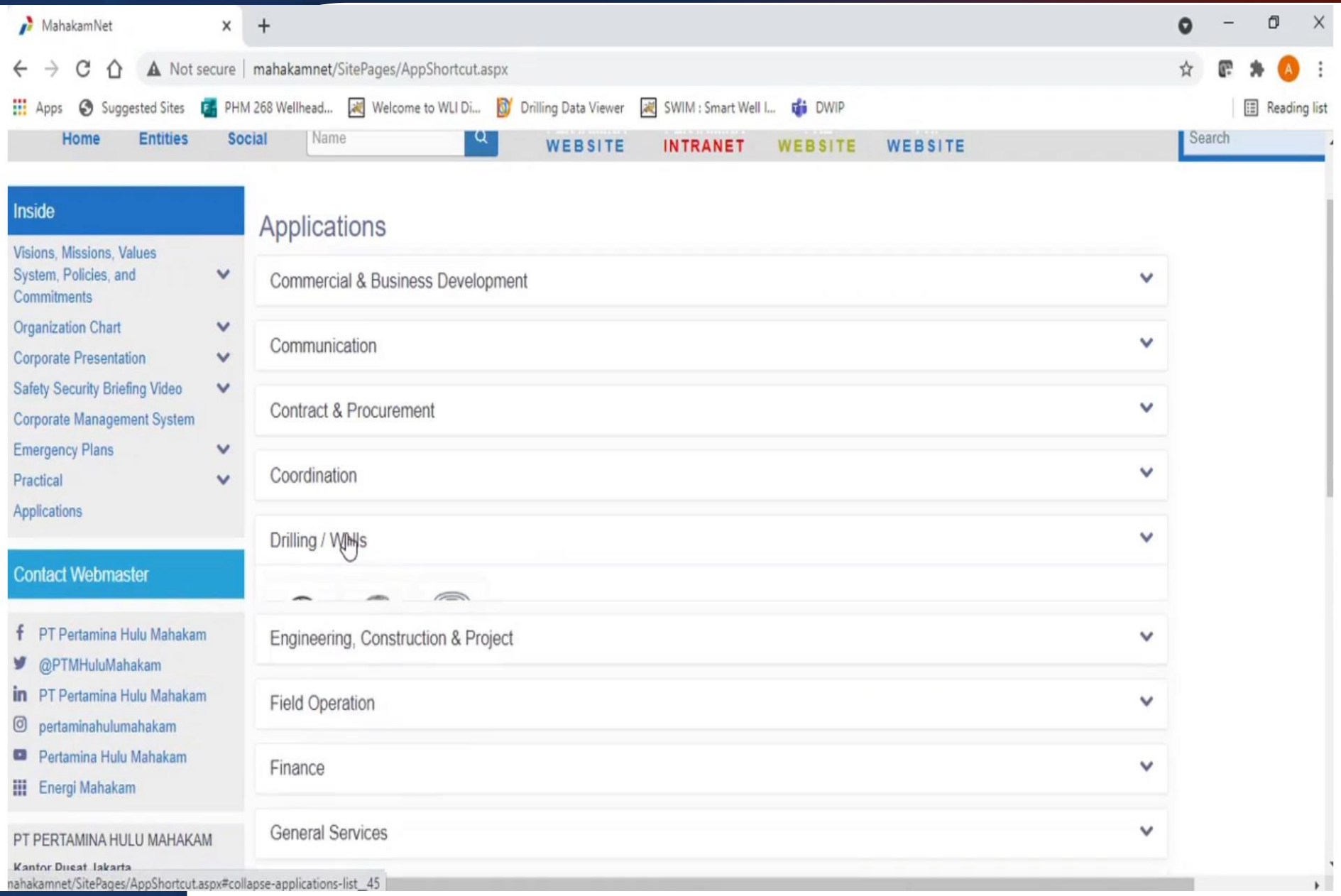
- Part of OPLL-2C follow up
- Candidate identification for pilot project
- JRA development
- Workflow definition
- Socialization to Site

2023

- JRA socialization to Site
- VSP at Pilot well TN-S182
- VSP Campaign at TN-S189, TN-S214, TN-AA304, TN-S163

2024

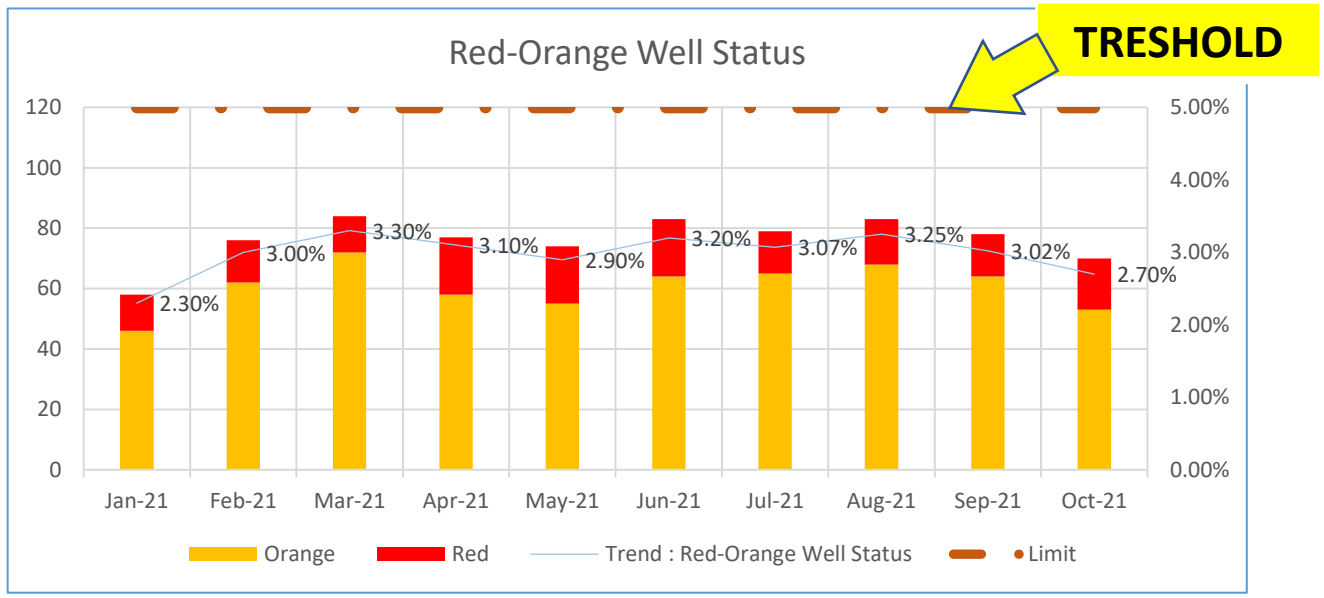
- Evaluation of VSP Project
- Planning for industrialization and standardized in TKO
- VSP Execution at TN-AA384 and TN-AA230
- Well review VSP candidate

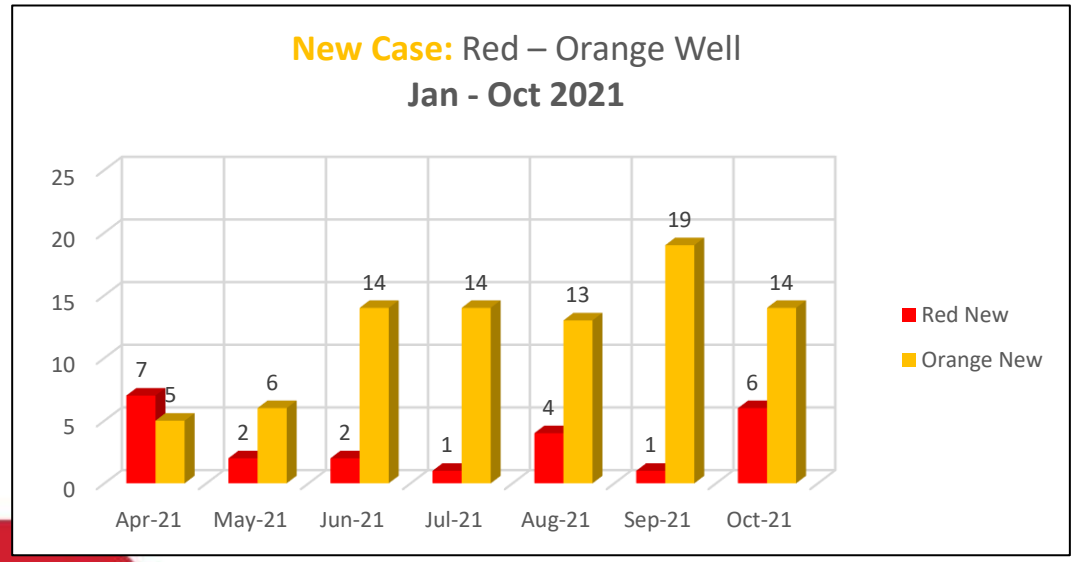


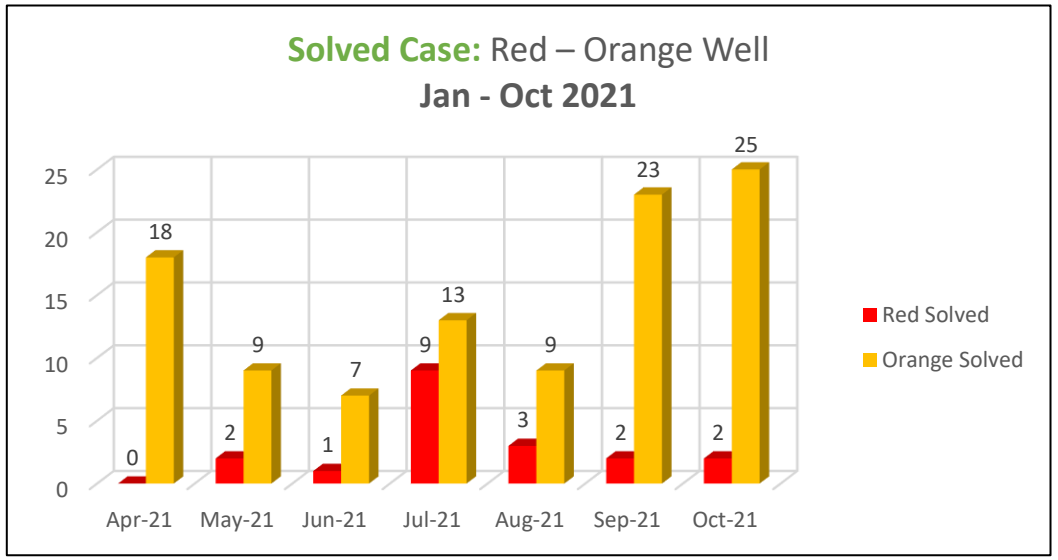
SMART WELL INTEGRITY MODULE

All monitoring activities has been managed through digital platform SWIM (Smart Well Integrity Module)

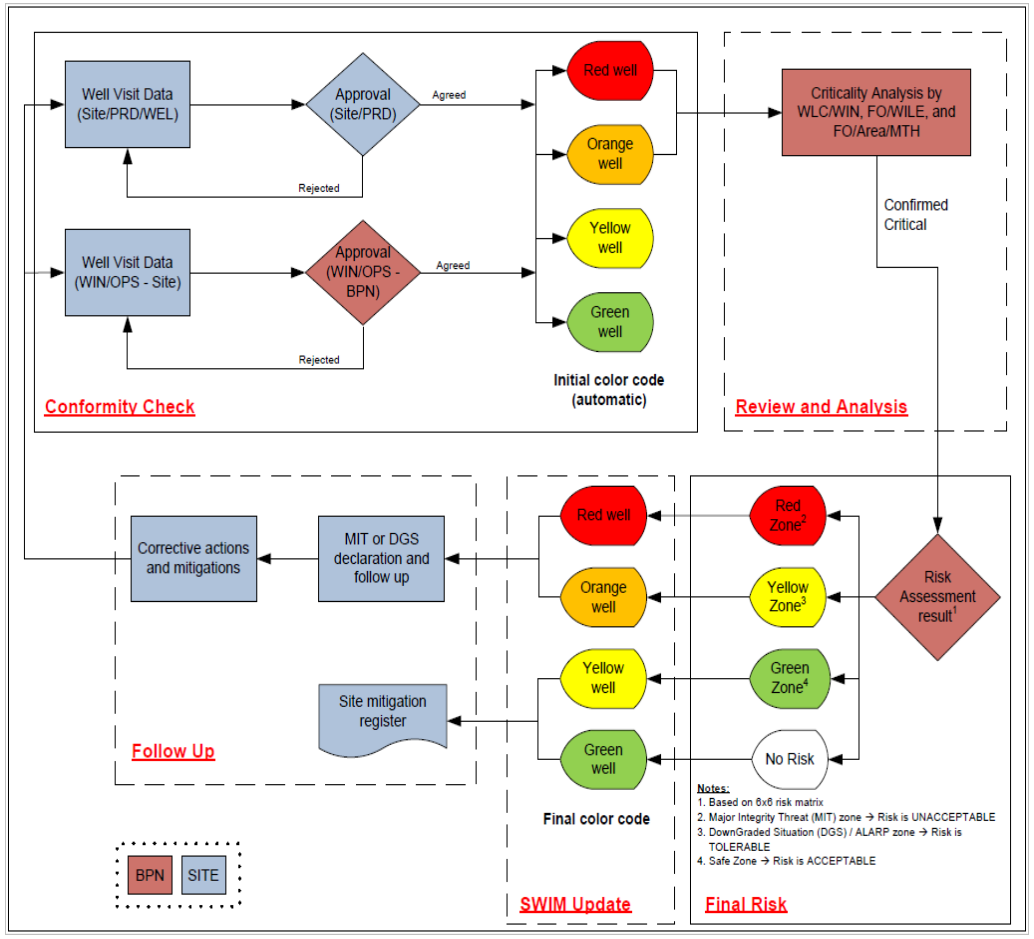
WELL INTEGRITY KPI







SMART WELL INTEGRITY MODULE (SWIM)



SWIM
Smart Well Integrity Module

The SWIM program has been used to record all the well integrity aspects for 2300++ wells within PHM perimeter.

The variability and combination of well locations and period of well installation have been becoming contributing factor to our extra effort for defining barrier element data. The summary are as follows:

External Barrier with its combination of element identification.

Internal Barrier with its combination of element identification.

Color Code	Green	Yellow	Orange	Red
General Definition	Annulus Pressure, Internal and external well envelopes in good condition and no degradation	Annulus Pressure, Internal and external well envelopes in good condition but one or more aggravating factors exist with acceptable risk	One well envelope, internal or external, Annulus Pressure is failed. A single failure of a barrier may lead to leak to environment	Annulus Pressure, Internal and external well envelopes are failed or when leak is observed at surface

All monitoring activities has been managed thru digital platform SWIM (Smart Well Integrity Module)

Specific Mitigation

Pilot Well VSP Mitigation Refer to JRA

✓ **Subsurface**

- Well candidate avoid GTS-C area considering well integrity risk due to potential reservoir connectivity with ex-blowout well
- Ensure pressure from reservoir not exceeding the shallowest perforation fracture pressure refers to PPFG data
- Ensure minimum requirement of 50 m accumulative shale layer thickness

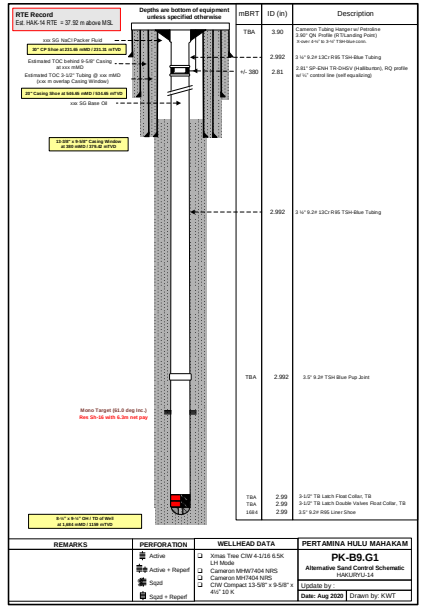
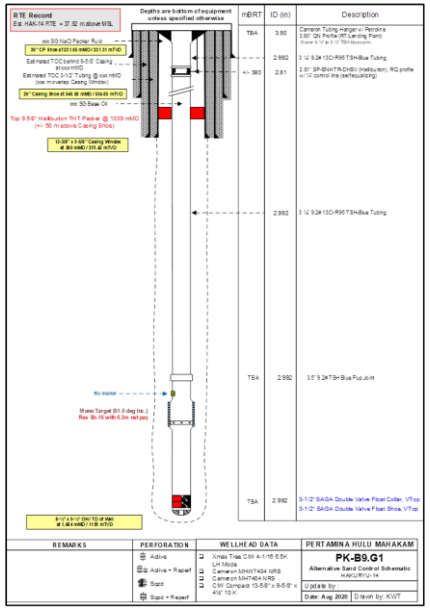
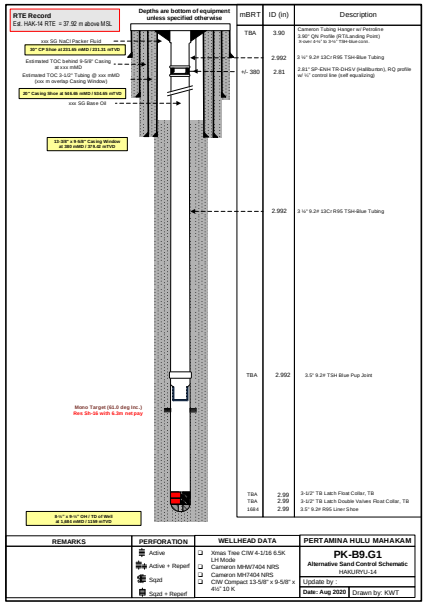
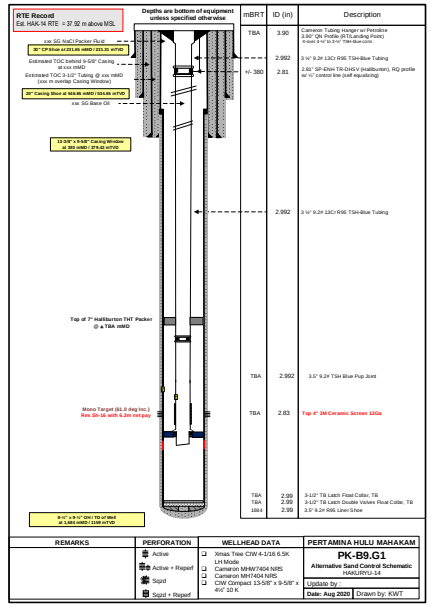
✓ **Well Intervention**

- Validation of well barriers
- Utilization of multi-purpose barge and well testing barge is ready to mobilize to accommodate well killing capability
- Noise log to be performed post perforation only if LR > 15 scfm observed
- Cement quality validated by cement checklist and CBL/VDL logging
- Perform punch prior main perforation
- Setting screen as sand control means

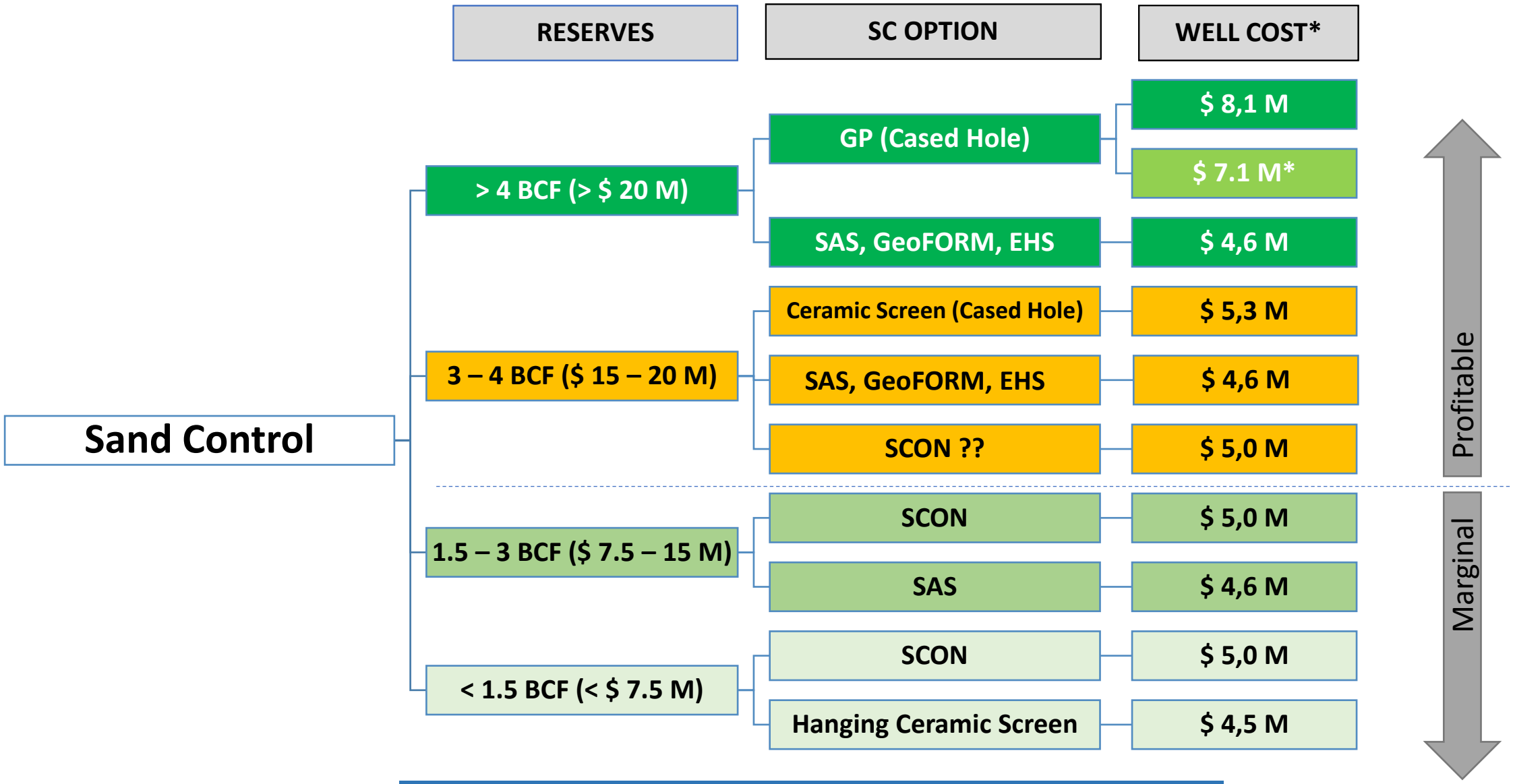
✓ **Production Operation**

- Installation of bleed off line with PSV in Annulus
- Daily well monitoring post perforation until consider stable
- PSHH flowline set below fracture pressure
- Ensure mitigation to produce sand wells, such as ; use sand resistance choke valves, sand probe installed, etc

COST RANKING

	SCON	SAS OH	Thru Tbg Ceramic	Monobore Ceramic
				
Drilling (Completion) Duration	13 Days (2.5 days)	13 Days (2.5 days)	13 Days (2.5 days*)	13 Days (20 days*)
Tangible Cost	US$ 201K	US$ 366K	US$ 200K	US$ 664K
Intangible Cost	US$ 4,804K	US$ 4,285K	US$ 4,358K	US$ 4,708K
Perfo & 1 Sand Control Cost	US$ 546K + 84K	US$ 114K	US$ 100K	US$ 125K
Perfo & 2 Sand Control Cost	US$ 1,093K + 162K	US$ 162K	US$ 162K	US$ 100K++
TOTAL COST PER WELL	5,0 M	4,6M	4,5 M	5,3 M

Sand Control Selection



Stake will determine Sand Control Selection

SCON MILESTONE

Cured resin sample

2018
SandTrap 225/350
HALLIBURTON

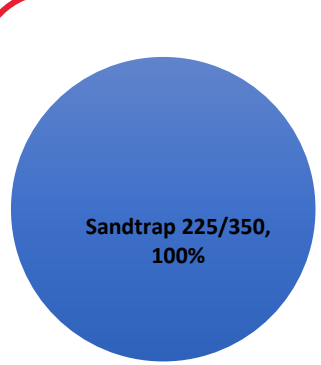
2019
Sandlock V
Schlumberger
Sandtrap ABC
Sandtrap 225/350
HALLIBURTON

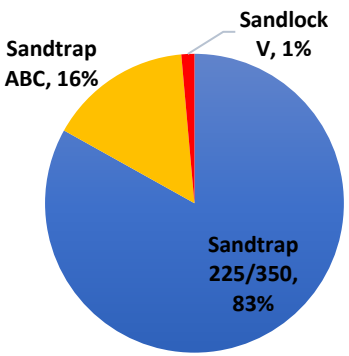
2020
Sandlock V
Schlumberger
Sandtrap ABC
Sandtrap 225/350
HALLIBURTON

2021
SacTi-01
TITIAN
SC3 Furan
Baker Hughes
Sandtrap ABC
Sandtrap 225/350
HALLIBURTON

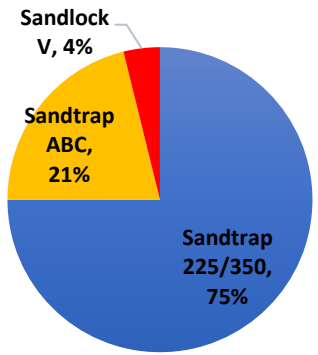
2022
Aquaset
Schlumberger
SacTi-01
TITIAN
SC3 Furan
Baker Hughes
Sandtrap ABC
Sandtrap 225/350
HALLIBURTON

2023
Trial
Bio-Scon
SRIJAN Caliche
SacTi-01
TITIAN
Sandtrap ABC
Sandtrap 225/350
HALLIBURTON

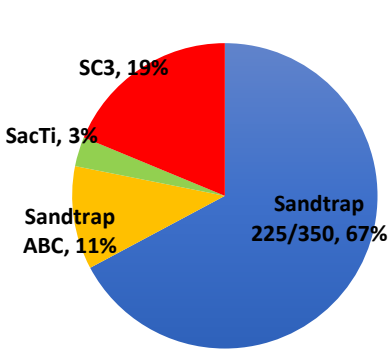




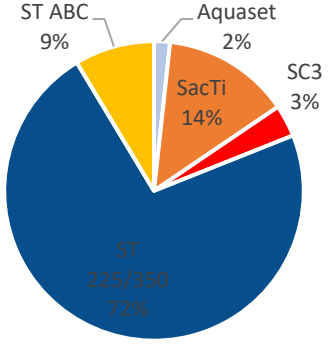
71 job



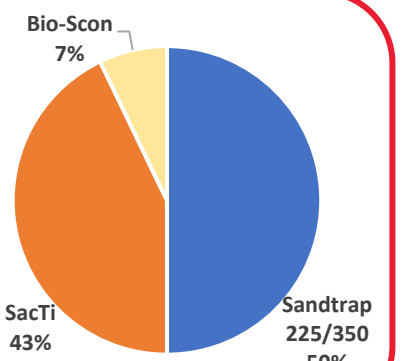
52 job



62 job



66 job

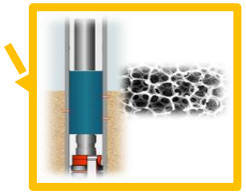


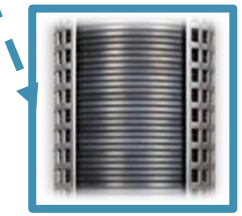
63 job

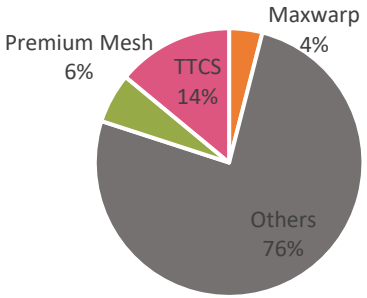
SCREEN MILESTONE

Sand Screen development and workload in Mahakam

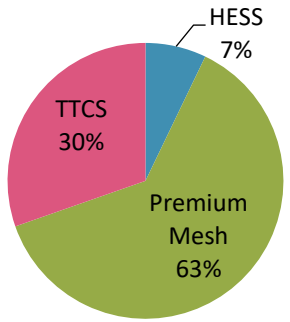
2020	2021	2022	2023
Others		Filtrex	Bead Screen
Wire Wrap	HESS	HESS	Multi weave
Premium Mesh	Premium Mesh	Premium Mesh	Boron
TTCS	TTCS	TTCS	Filtrex
			HESS
			Premium Mesh
			TTCS



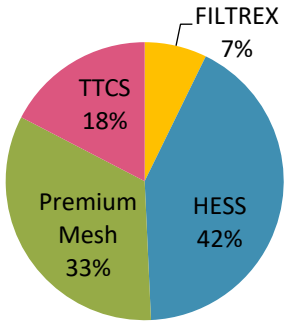




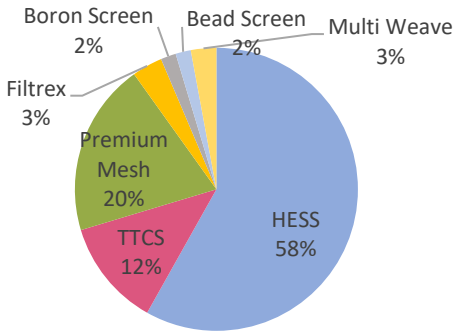
50 job



56 job

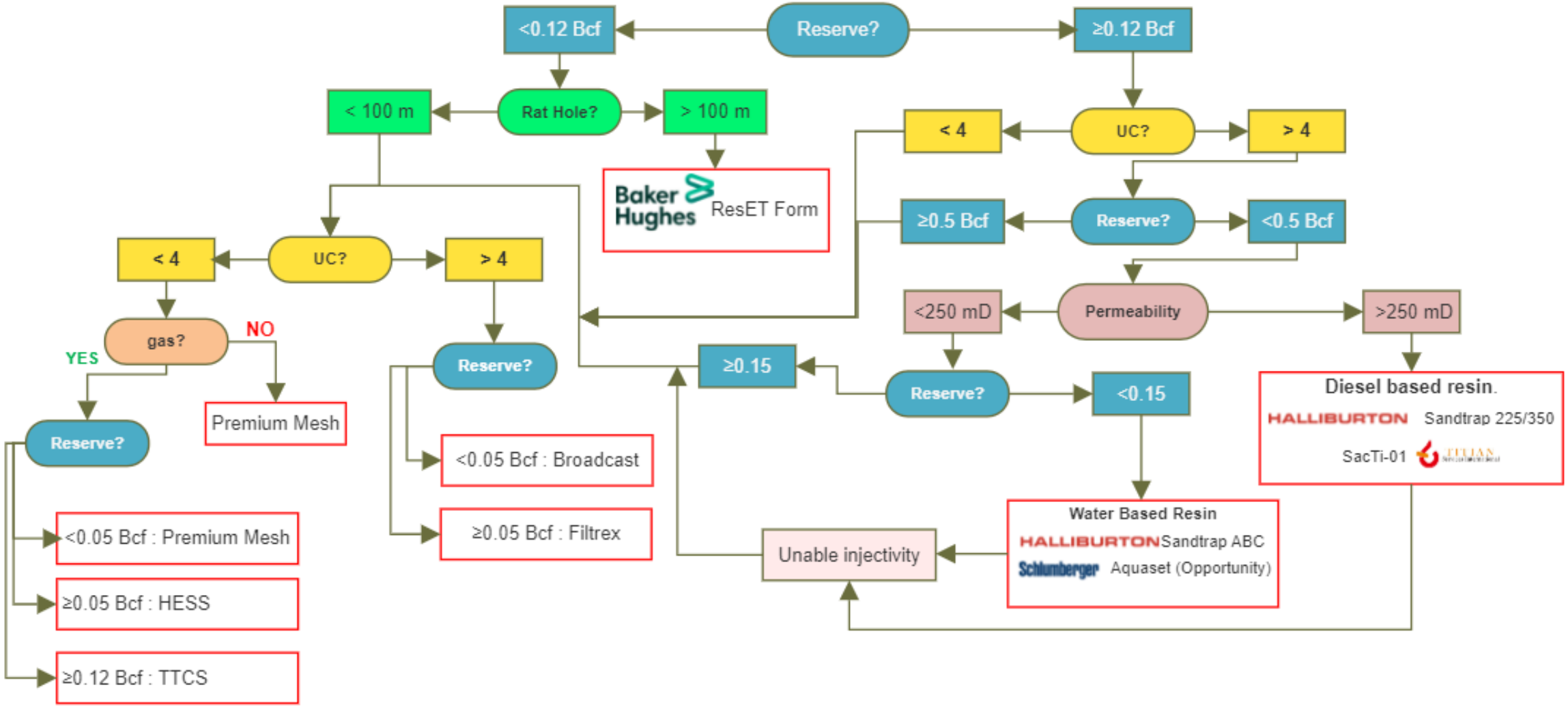


65 job



172 job

Sand Control Selection



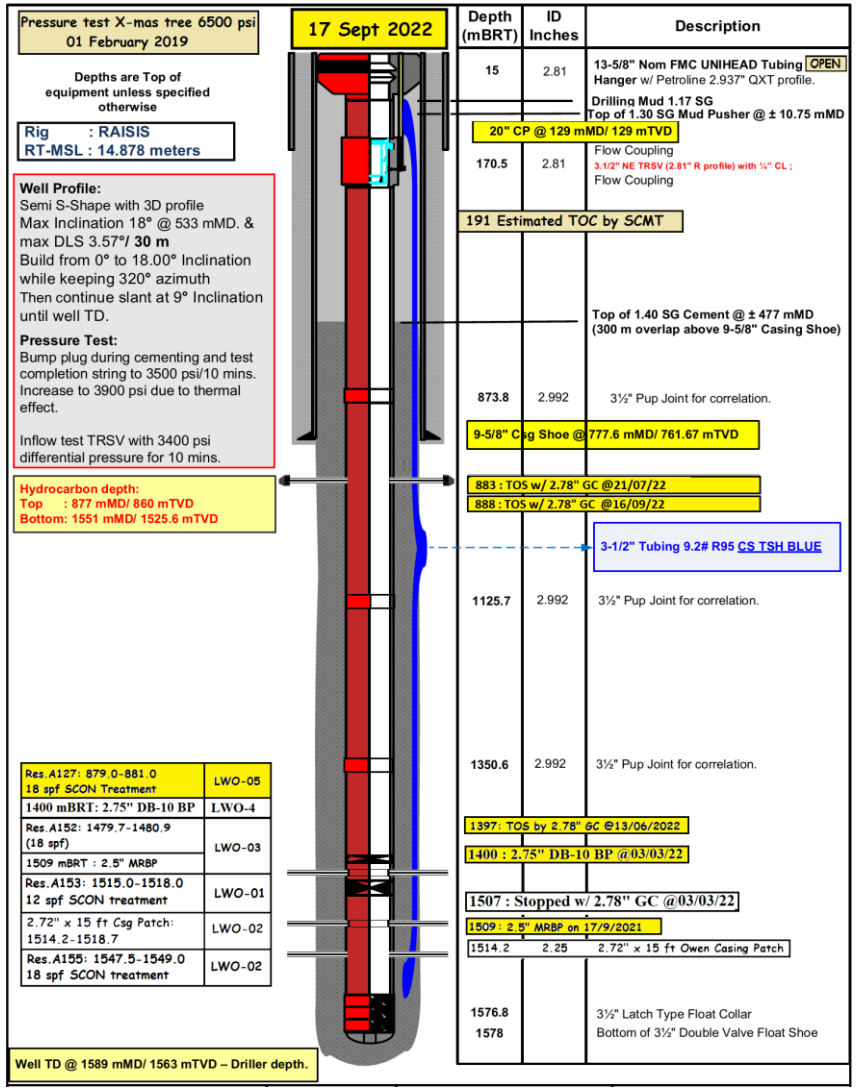
TRIAL RESULT

No	Well	Well Architecture	Reservoir Information				Well Intervention Key Parameter			Perfo & Clean Up Date and Clean Up Result			
			Reservoir	Depth (mTMD)	Depth (mSS)	Prognosis : bcf, MMscfd	Cement Quality	Ann Pressure Prior VSP (psi)	(WHSIP) & Ann Pressrure after VSP (psi)	Perforation Date	Clean Up Date	Clean Up (MMscfd)	
1	TN-S1XX	SLA	A108	411.6 - 412.7	394.7 - 397.2	0.12, 1	Good, est TOC at 191 mBRT	Ann A/B : 0/101	(700), Ann A/B : 0/101	31-Mar-23	4-Apr-23	0.63	
4	TN-S1XY	SLA	A109	354.9 - 356.9	319.8 - 321.4	0.11,1	Good to poor, est. TOC at surface	Ann A/B : 0/67	(432), Ann A/B : 432/67	21-Nov-23	24-Nov-23	1	
3	TN-S2XX	SLA	A113	522.6 - 524.6	477.3 - 481.0	0.07, 1	Good, est TOC at surface	Ann A/B : 0/0	(467), Ann A/B : 0/0	30-Nov-23	7-Dec-23	0.44	
4	TN-AA3XX	OPW	A117	502.6 - 503.5	472.4 - 473.3	0.11,1	Good, est. TOC at surface	Ann A : 0	(430), Ann A : 0	14-Dec-23	16-Dec-23	No Flow	
5	TN-S1XZ	SLA	A123	543.6-544.2	475.7 - 475.5	0.03, 1	Good, est. TOC at 392 mBRT	Ann A/B/C : 523/0/0	(644), Ann A/B/C :	1-Jan-24	13-Feb-24	No Flow	
6	TN-AA3XY	OPW	A117	491.2 - 492.7	446.8 - 448.1	0.06	Good, est. TOC at surface	Ann A : 3	(541), Ann A : 3	2-Jul-24	12-Jul-24	1.15	
7	TN-AA2XX	OPW	A112	512.2 - 512.7	486.3 - 486.8	0.03	Good, est. TOC at surface	Ann A : 5	(370), Ann A : 3	10-Jul-24	TBC	Waiting set screen and clean up	

Notes:

1. Total 7 very shallow target has been perforated.
2. Shallowest SLA target: 319.8 mSS
3. Shallowest OPW target: 446.8 mSS

VERY SHALLOW PERFORATION CASE



Res Name	Top Perfo (mMD)	Bottom Perfo (mMD)	Top Perfo (mSS)	Bottom Perfo (mSS)	Netpay ABC (m)	Contact	Avg Phi (%)	Avg Vsh (%)	Avg Perm (MD)	Pressure (psi)	2P Stakes
A108	411.6	412.7	394.6	395.6	2.52	GWC	29%	26%	1550	576	0.12

Highlight prior perforation:

1. This well is SLA (consist of 2 Annulus), presence of Annulus pressure in Ann#B 6 – 7 Bar (MAWOP 15 B) with Leak Rate < 3 scfm.
2. Noise log result while venting Ann#B shows noise indication at 125 m and no connection to Res. A108.