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A HOLISTIC APPROACH FOR PRODUCTION OPTIMIZATION STRATEGY IN BEKAPAI OFFSHORE FIELD

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Abstract. This paper describes optimization efforts that have been done, currently in execution and will be done in Bekapai. These efforts are from subsurface point of view and also surface facilities.

Bekapai is a mature oil and gas field located in the offshore Mahakam Delta, Indonesia. Since future development resources become more limited, optimizing existing wells or baseline potential is one of the key to prolong the life of Bekapai. Some key works have been done such as, revisit fluid interpretation of old wells, update hydrocarbon contact based on new wells data and PLT or RST result and detail dynamic synthesis on reservoir level to reconcile hydrocarbon in place and production cumulative. Other than new wells, several optimization efforts are performed to Maintain baseline contribution.

Some of these optimization efforts are considered as conventional but yet still deliver good result, such as gravel pack zone reopening; Lowering network pressure by adjusting wells configuration and review again fluid status of our reservoirs to increase the perforation portfolio. Other efforts are considered as breakthrough in Bekapai field, such as well to well gas lift injection; inter platform gas lift injection and sand consolidation (SCON) treatment.

SCON is recently performed to produce unconsolidated reservoirs in Bekapai with very good result, reserves realization is higher than prognosis. All these efforts are success to Maintain baseline contribution in Bekapai at 50-65% of total field production. Beyond current practice, gas lift Deepening is one of the methods to be implemented soon, to optimize oil production and Lowering the abandonment pressure of depleted zone.

The success of these optimization efforts illustrates the value of continuous improvement and holistic approach between related entities in optimizing production from a mature oil and gas field.

Keyword: Mature Oil and Gas Field; Baseline Production; Aging Surface Facility; SCON

1 Introduction

1.1 Subsurface Overview

Bekapai is oil & gas field located in offshore water depths of 30-40 m, to the south east of Mahakam delta, 15 km of east Kalimantan coastal line. Consist of multilayered reservoirs: Shallow, Main, Upper, Lower & Deep zone, with strong aquifer support in Shallow – Upper and natural depletion in Lower - Deep. Multiple faults (impermeable) were found and it split Bekapai into three panels: West, Central & East panel, which most of accumulation and development located in West panel (Figure 1).

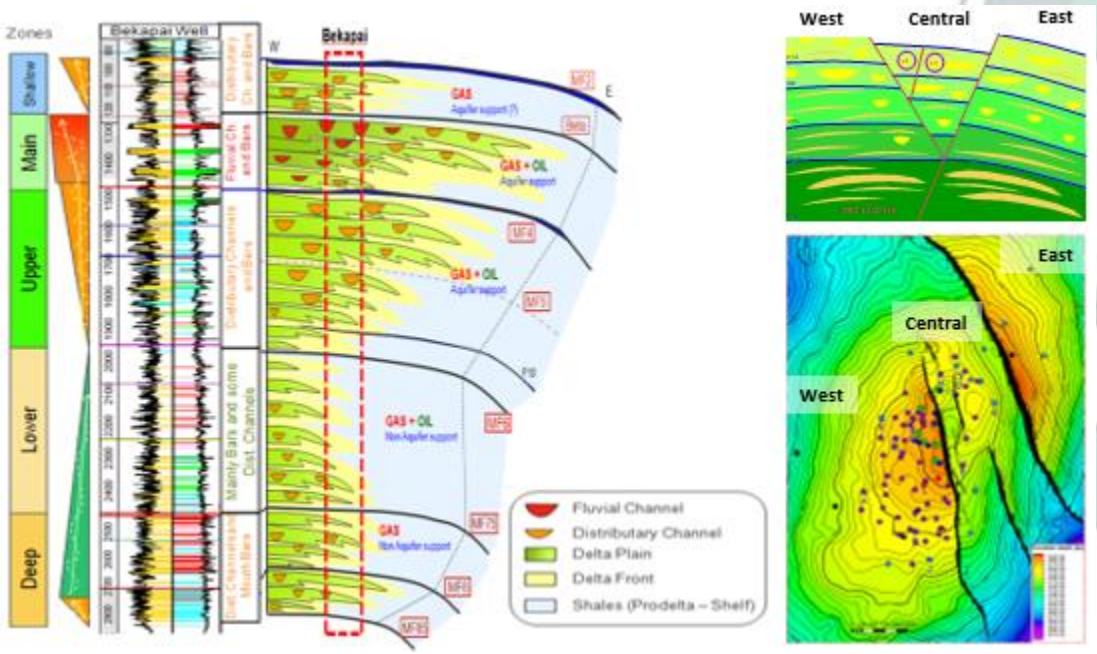


Figure 1. Bekapai Subsurface Overview

Main challenges are: sand prone reservoir in Shallow – Upper zone, lifting issue in Lower - Deep zone, risk of well die due to water, comingles production & depletion (sensitive).

1.2 Surface Overview

Production started from a single well as a pilot project in July 1974 and a year later, the first multi-well production platform was installed and the field was officially inaugurated on December 1975. In the early years of field, production was high, particularly from Main zone. All Bekapai production is transferred to offshore Bekapai process facilities to separate and to treat liquids and gas before sending it to the onshore processing center at Senipah. The wells were capable of producing 4,000 to 5,000 BOPD. In 1978, Bekapai reached its peak production with 58,000 BOPD.

After a long period of natural decline, between 2007 – 2020 series of re-developments were proposed and executed to prolong Bekapai life (Ph.1, Ph.2A, Ph.2B & Ph.4). Total 10 platforms (BK, BH, BE, BF, BA, BB, BJ, BC, BG, BL) & 99 wells were developed/drilled until today (Figure 2). However as per now (September 2020), only 4 platforms (BG, BL, BH & BJ) & 18 wells are active, with total production ~32 MMscfd & 6,000 BOPD. Some in-active platforms are waiting for new well development and others have been converted into processing platform or hub.

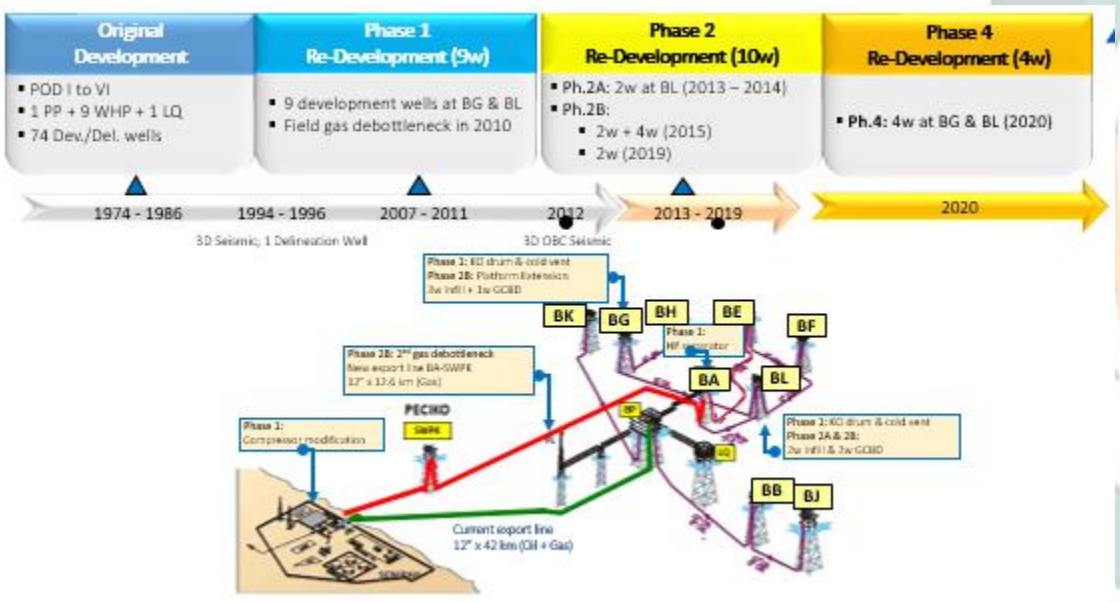


Figure 2. Bekapai Surface Overview

Main challenges are: aging surface facilities (~46 years) lead to repetitive SD & limited means prior well recovery (no offloading pump & no gas lift compressor).

In conclusion with future development resources become more limited and natural decline can't be avoided, optimizing existing wells is one of the key to slow down natural decline. Holistic approach must be done in order to overcome subsurface and surface challenges in journey to prolong the life of Bekapai. Some key works have been done such as: gravel pack reopening, SCON & Screen treatment, well to well gas lift injection, lowering network pressure by adjusting well configuration, inter platform gas lift injection.

2 Methodology

2.1 Gravel Pack (GP) Reopening

As mention above Shallow – Upper zones are considered as sand prone reservoir and need sand control, in this case by gravel pack (GP), prior put on production. However, with combination of aquifer as main driving mechanism and comingles production in GP sections (most of the case 3 – 4 GP open at the same time) often considered as base case production strategy to boost production at early stage of well life, those lead to underperform GP sections at later stage of well life. When those happen, normally GP sections will be closed and production move to perforation in liner sections, left remaining potential in GP sections un-produced.

Gravel Pack Reopening is feasible solution to boost well performance, by reopening GP sections that still have remaining potential based on last PLT data, dynamic synthesis & recent information coming from new wells (Figure 3).

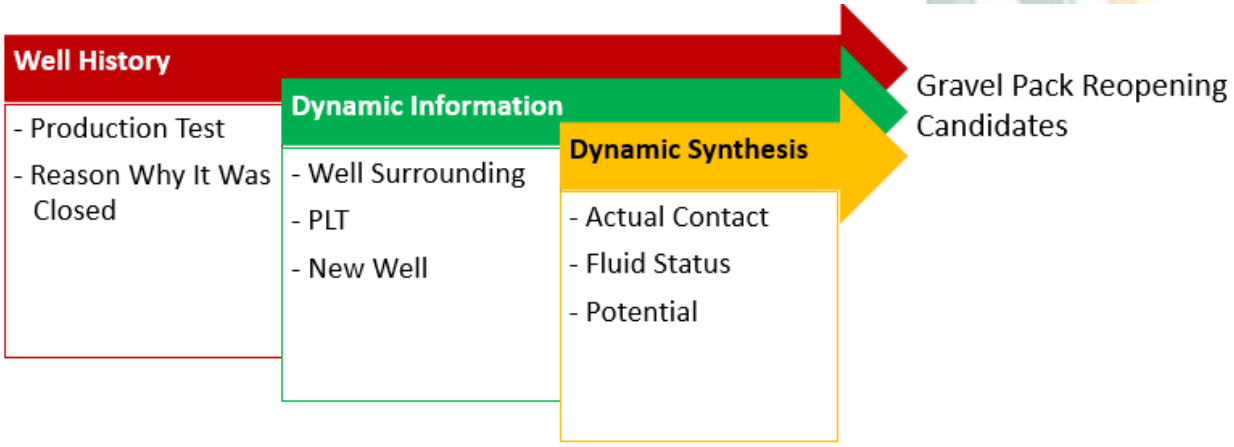


Figure 3. Gravel Pack Reopening Candidates Selection

One of recent case is B-18, In February 2020 B-18 was shut in due to unplanned shut down and loss potential. GP reopening was executed in July 2020, GP# 4 was re-open commingle with existing GP# 1 & liner sections, resulted gain 770 BOPD & 5 MMscfd at 20 bar WHFP (Figure 4). GP# 4 initially was closed in January 2018 due to underperformed during comingles production with GP# 1, 2 & 3. Latest potential before these zones closed was 290 BOPD & 5.9 MMScfd at 31 bar WHFP.

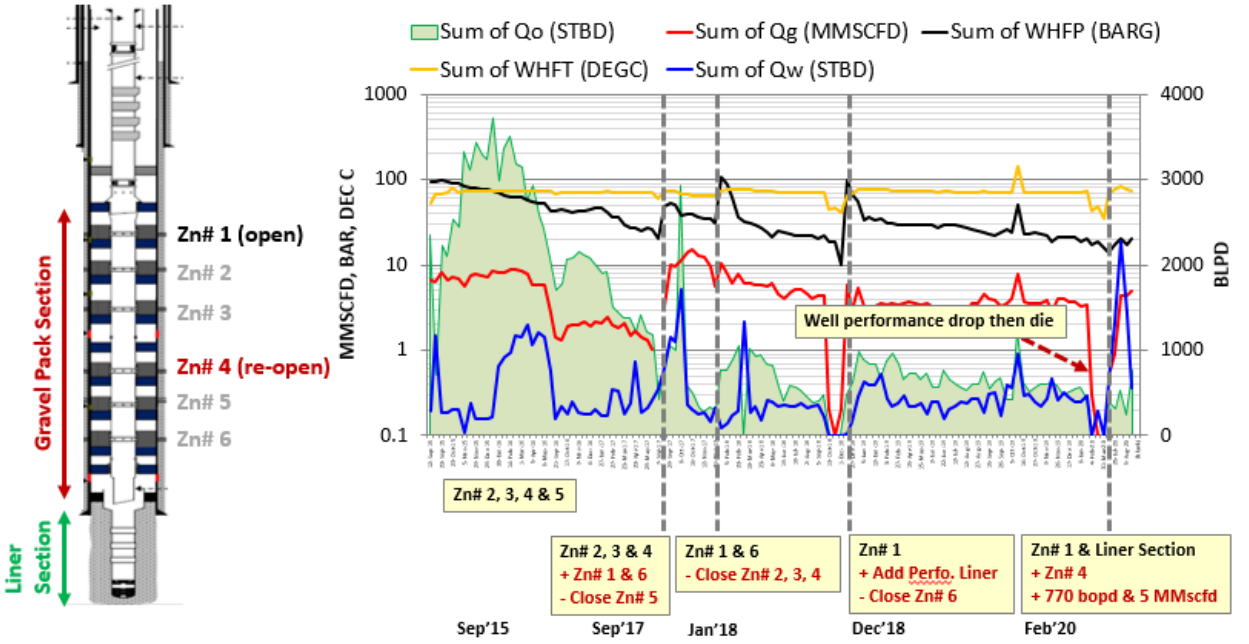


Figure 4. B-18 Well Diagram Illustration & Production Test

By knowing history of the well, recent dynamic information and performed dynamic synthesis, remaining potential in GP section can be identified and can be source to prolong baseline production.

2.2 SCON & Screen Treatment

Another option to produce sand prone reservoir in Shallow – Upper zone is production thru SCON & Screen treatment. These option will target Shallow – Upper reservoirs that have not been completed by GP during initial well completion. Normally it will be executed at the end of well life, when all GP and liner section have been produced.

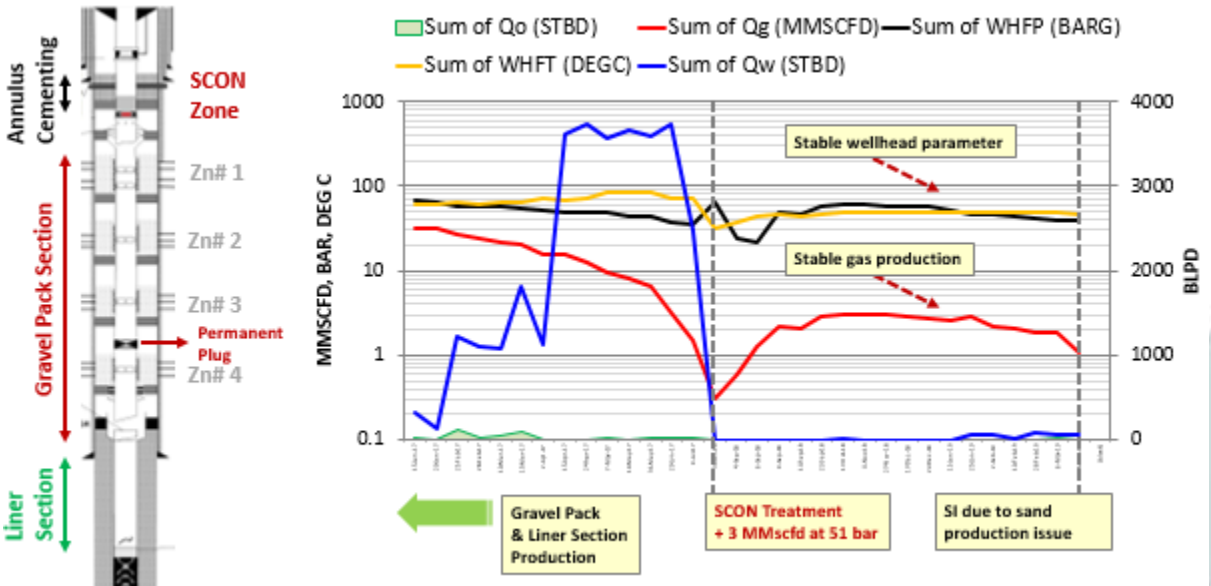


Figure 5. B-9 Well Diagram Illustration & Production Test

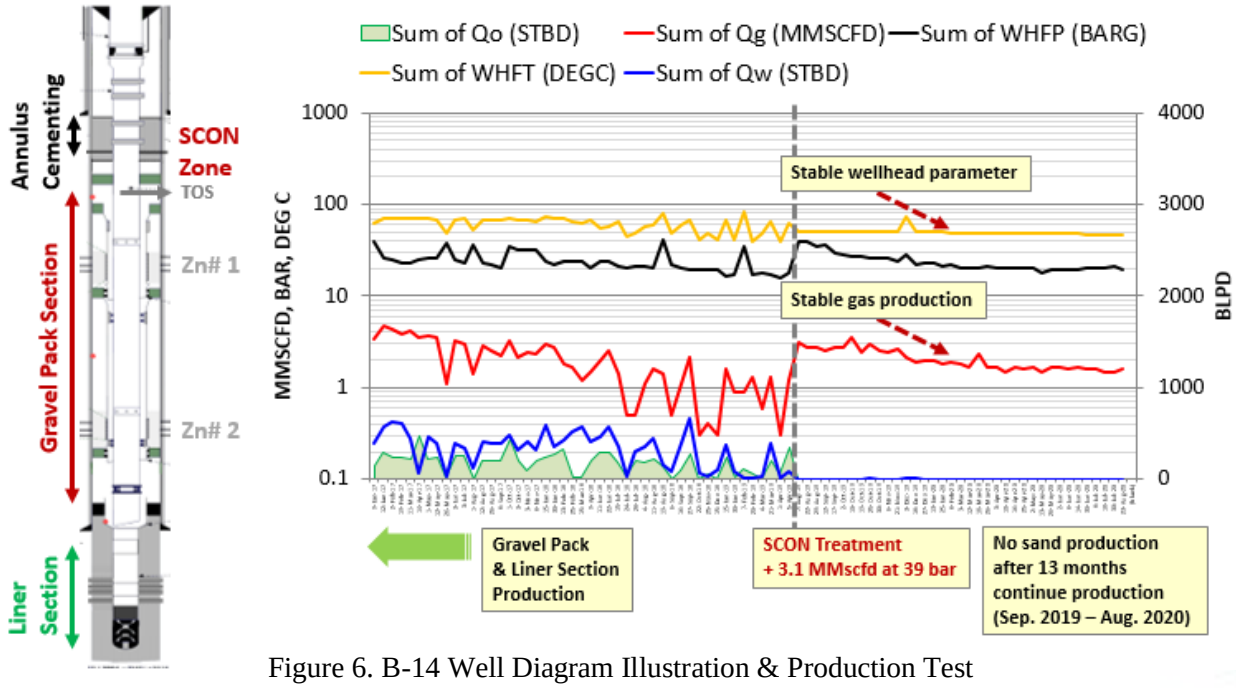
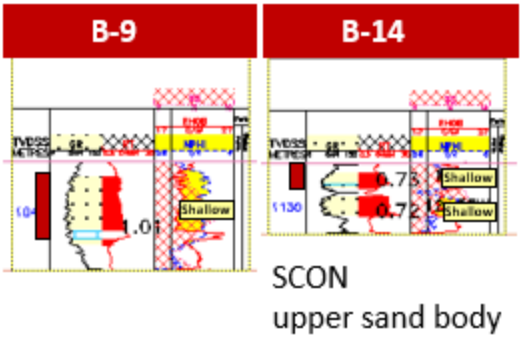


Figure 6. B-14 Well Diagram Illustration & Production Test



	B-9	B-14
NetPay (m)	10.0	2.1
Porosity (%)	29.0	25.0
V.Shale (%)	13.0	12.0
Initial Pressure (psi)	1,349	1,118

Figure 7. B-9 & B-14 Reservoir Properties

SCON treatment start in 2018, total 2 SCON wells have been POP so far (B-9 & 2019: B-14), with B-14 still produce until today. As per September 2020, cumulative production of B-9 is 0.55 Bcf, this is beyond initial prognosis 0.3 Bcf, production last 8 months (since September 2018), until sand production issue start in April 2019 (Figure 5). As for B-14 is 0.8 Bcf, this is beyond initial prognosis 0.3 Bcf, no sand production issue was observed since September 2019 (13 months after SCON treatment), can be seen in Figure 6.

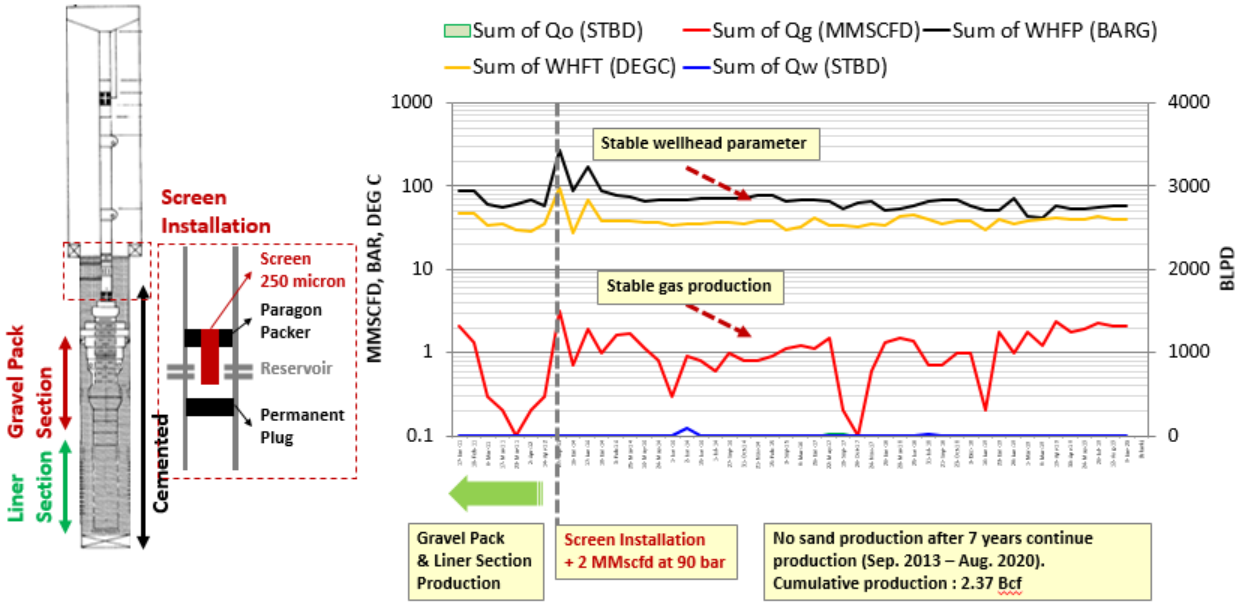
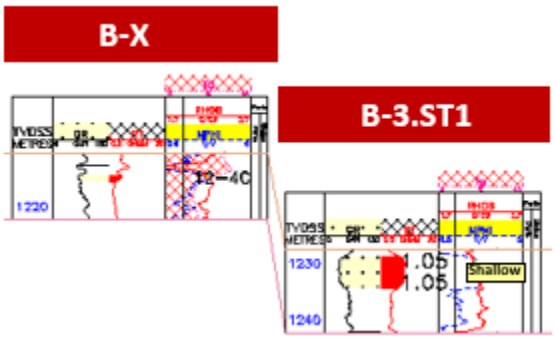


Figure 8. B-3.ST1 Well Diagram Illustration & Production Test



NetPay (m)	5.6
Porosity (%)	21.0
V.Shale (%)	27.2
Initial Pressure (psi)	1,746

Figure 9. B-3.ST1 Reservoir Properties

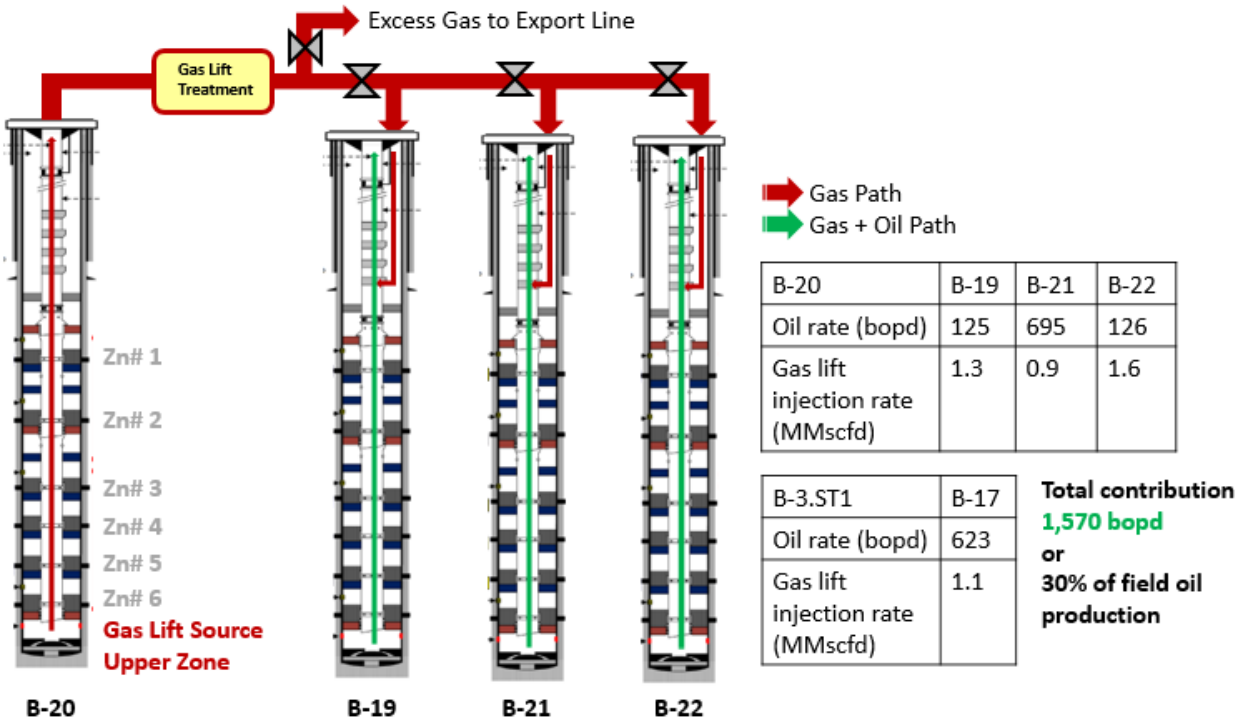
The only screen well in Bekapai is B-3.ST1, it was installed in September 2013, and since then continues production until today (7 years of production Sep. 2013 – Aug. 2020), with total cumulative production 2.37 Bcf (Figure 8 & 9). Due to its stability to deliver high pressure gas (2 MMscfd at 90 bar), B-3.ST1 also utilized as gas lift source for other wells (such as: B-17, B-21 & B-22).

Both SCON & Screen treatment provide good results, confirm by production realization (better than prognosis) and long production durability to avoid sand production. Both methods will be used for future Shallow – Upper zones development.

2.3 Well to Well Gas Lift Injection

Despite most of wells in Bekapai were equipped with gas lift mandrel, currently there is no gas lift compressor to provide closed gas lift system with constant pressure. Instead gas lift source is provided by dry gas wells with good wellhead flowing pressure (~60 bar). As of today (Sep. 2020) there are 2 wells that regularly used as gas lift source (B-3.ST1 & B-20), with both wells could deliver 1-3 MMscfd at 60-90 bar. Well to well gas lift system illustrated in Figure 10. All gas coming from gas lift source wells will be delivered to injected wells thru gas lift treatment system, where all liquid will be drained and dry gas will be injected in each injected well (controlled by valve in each well). Excess gas will be delivered to export line (Figure 10).

Gas lift injection has been used to help wells with lifting issue (B-17, B-19, B-21 & B-22), but sometimes it has been used to help well recovery post shut down. Gas lift injected well contribution to field production is quite significant. In 2020 gas lift injected well contribution is equal to 30% of field oil production (1,570 BOPD), some of example is injection case in B-22 by B-20 (Figure 11 & 12)



B-20	B-19	B-21	B-22
Oil rate (bopd)	125	695	126
Gas lift injection rate (MMscfd)	1.3	0.9	1.6

B-3.ST1	B-17
Oil rate (bopd)	623
Gas lift injection rate (MMscfd)	1.1

Total contribution 1,570 bopd or 30% of field oil production

Figure 10. B-20 Well to Well Gas Lift Illustration

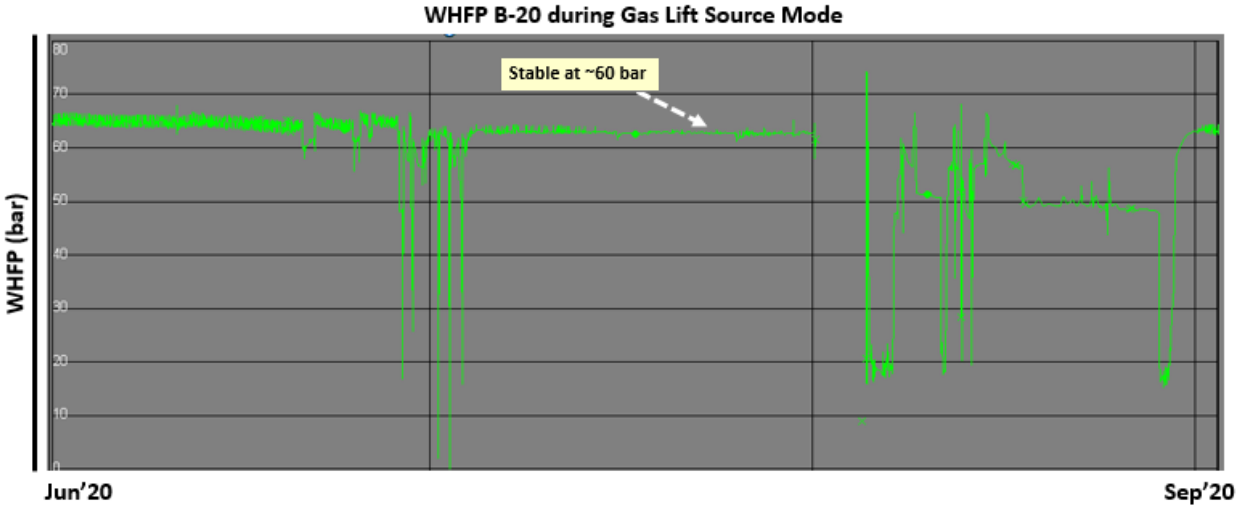


Figure 11. B-20 Wellhead Flowing Pressure during Gas Lift Source Mode

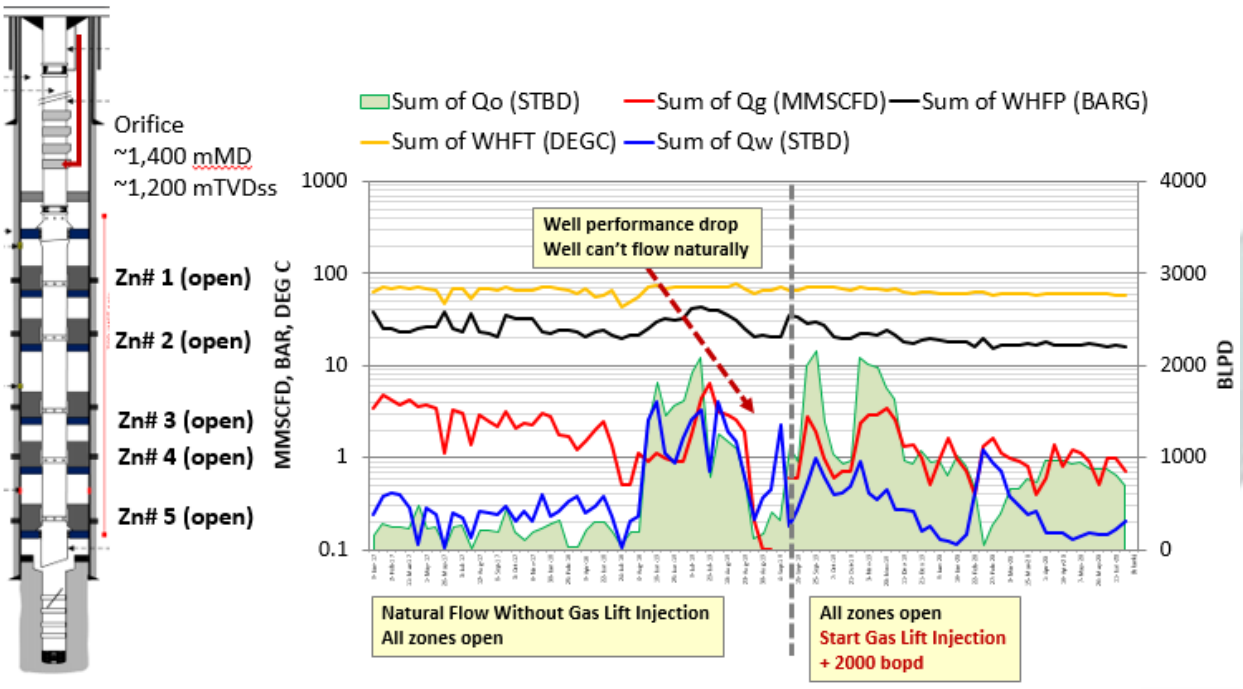


Figure 12. One of example Gas Lift Injected Well B-22

2.4 Lowering Network Pressure by Adjusting Well Configuration

There are two production routing at Bekapai which distinguished by HP production mode (utilized 12-inch production network) and LP production mode (utilized 6-inch production network). The 12-inch production network, with four times larger production area than 6-inch network, was used dedicatedly as main gas producer line (stronger wells). Figure 13 shows production figure and backpressure to well back in the peak gas production phase (with main producer platform BG and BL at that time), can be seen in Figure 13.

Since gas production profile decreases over time, it was decided to change the network concept to ensure the minimum backpressure possible for the wells since 2018. 12-inch production network has been utilized as LP production network (weaker gas with high liquid), while 6-inch production network has been dedicatedly utilized as HP production network (stronger gas with small liquid). Recent example of this new concept is what happen in January 2019 when production increase +985 BOPD by re-configuring HP-LP wells (Figure 14 & 15).

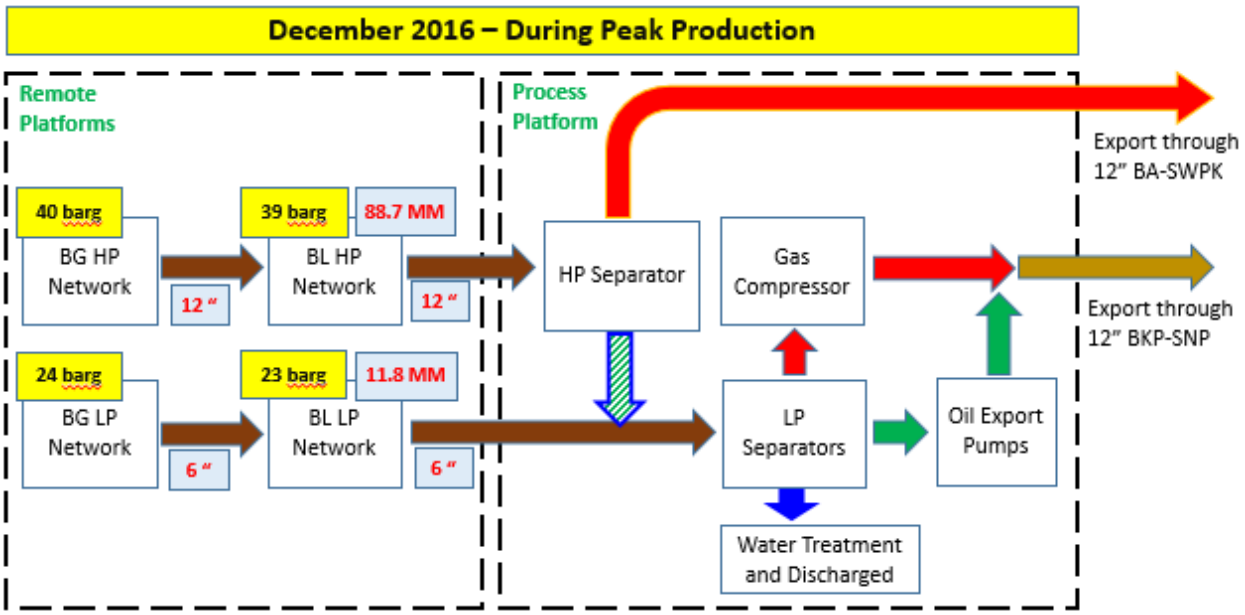


Figure 13. HP-LP Network Pressure During Peak Production in 2016

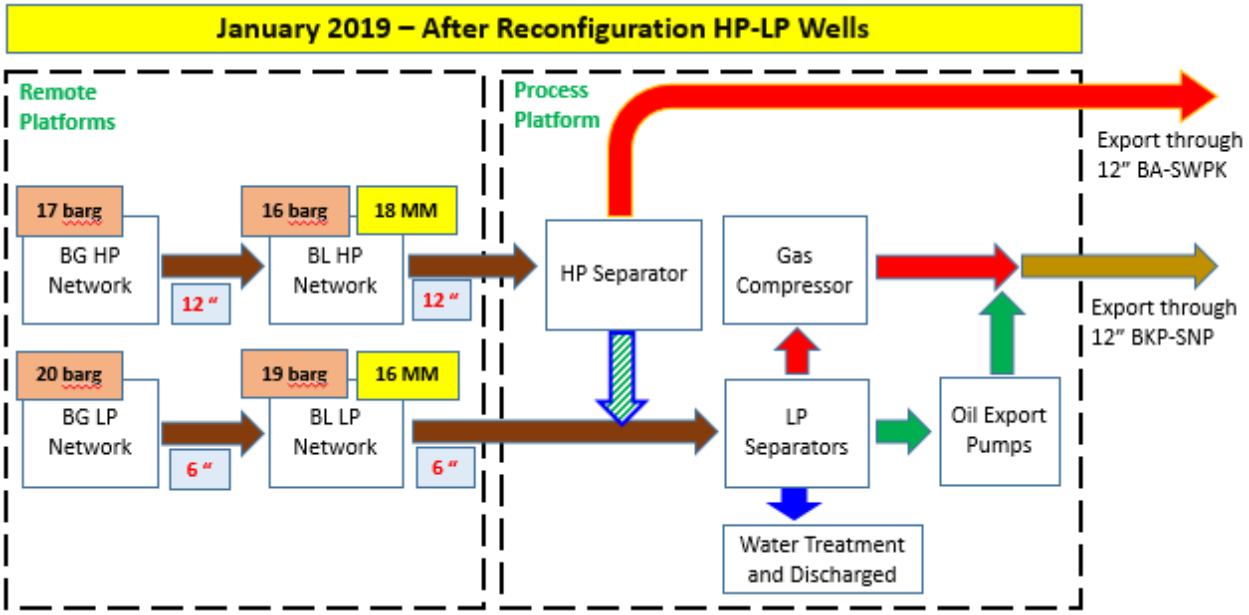
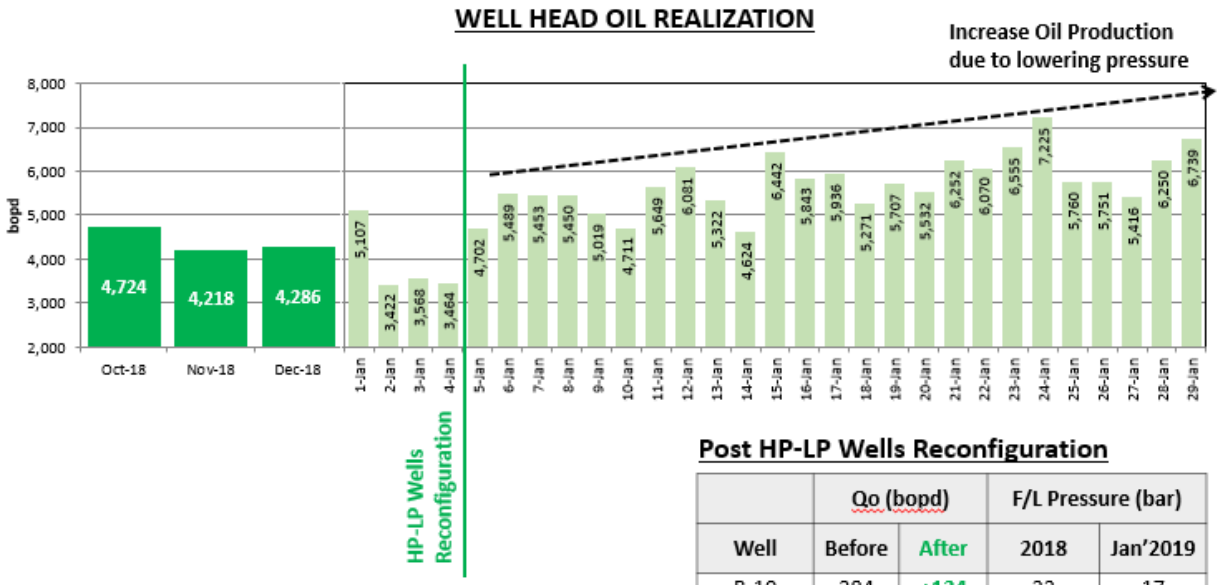


Figure 14. Recent Example HP-LP Wells Reconfiguration in January 2019



Post HP-LP Wells Reconfiguration

	Qo (bopd)		F/L Pressure (bar)	
Well	Before	After	2018	Jan'2019
B-10	384	+124	22	17
B-19	250	+194	22	17
B-1	90	+118	23	21
B-14	0	+232	SI No Flow	16
B-15	284	+290	20	16
	Total	+958		

	Before (2018)		After (Jan'2019)	
	Gas	Liquid	Gas	Liquid
6"	14.0	6,439	15.7	1,838
12"	20.0	2,153	18.3	6,754

Well	Gas	Oil	Water	Before (2018)	After (Jan'2019)	Well Head Pres. Bar	F/L Press. (bar) Before (2018)	F/L Press. (bar) After (Jan'2019)
B-10	0.9	384	322	6"	12"	22.3	22	17
B-14	0.2	251	963	6"	12"	23.6	22	17
B-15	1.3	100	50	12"	HP	17	16	17
B-17	0.2	434	104	6"	12"	22.5	22	17
B-18	0.1	0	0	6"	6"	22.4	22	20
B-19	0.6	250	130	6"	12"	22.6	22	17
B-20	3	29	200	GL Source	GL Source	75	68	70
B-1	0.3	90	119	6"	6"	25	23	21
B-3.ST1	1	0	0	GL Source	GL Source	54	53	70
B-4	1	121	298	6"	6"	42.5	12	14
B-1	3.2	68	293	6"	12"	29	20	16
B-6	6	36	121	12"	6"	16	15	18
B-9	2.7	0	1	6"	6"	53	20	18
B-15	2.7	284	1078	6"	12"	24.5	20	16
B-16	0.2	840	409	6"	12"	21.5	20	16
B-17	5.3	666	386	12"	6"	74.5	16	18
B-18	5.3	627	167	12"	12"	40	16	16

Figure 15. Recent Example HP-LP Wells Reconfiguration in January 2019

2.5 Inter Platform Gas Lift Injection

Previous design for well to well gas lift injection was only limited in the same platform. Gas producer well with high WHFP (~60 barg) is utilized as gas lift source for weak wells in the same platform. This initial design has vital disadvantages since gas lift source well should be in the same platform as producing wells.

The pilot project for this configuration was performed to provide gas lift from B-3.ST1 (BH Platform) to B-17 (BL Platform) in 2019. This configuration has been used until now with average production gain 623 BOPD since its first utilization (Figure 17). Simplified Inter-Platform Gas Lift block diagram presented in Figure 16.

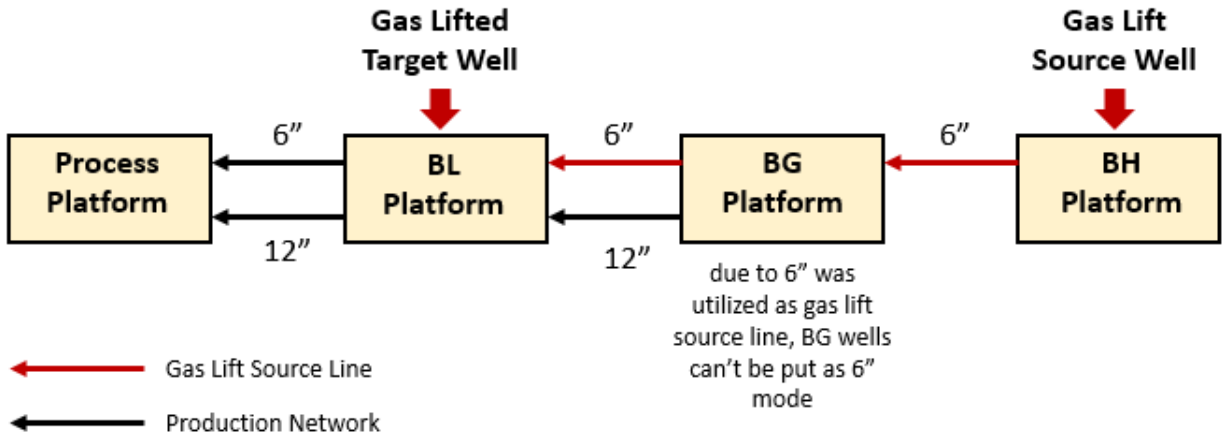


Figure 16. Inter Platform Gas Lift Injection Illustration (BH-3.ST1 to B-17)

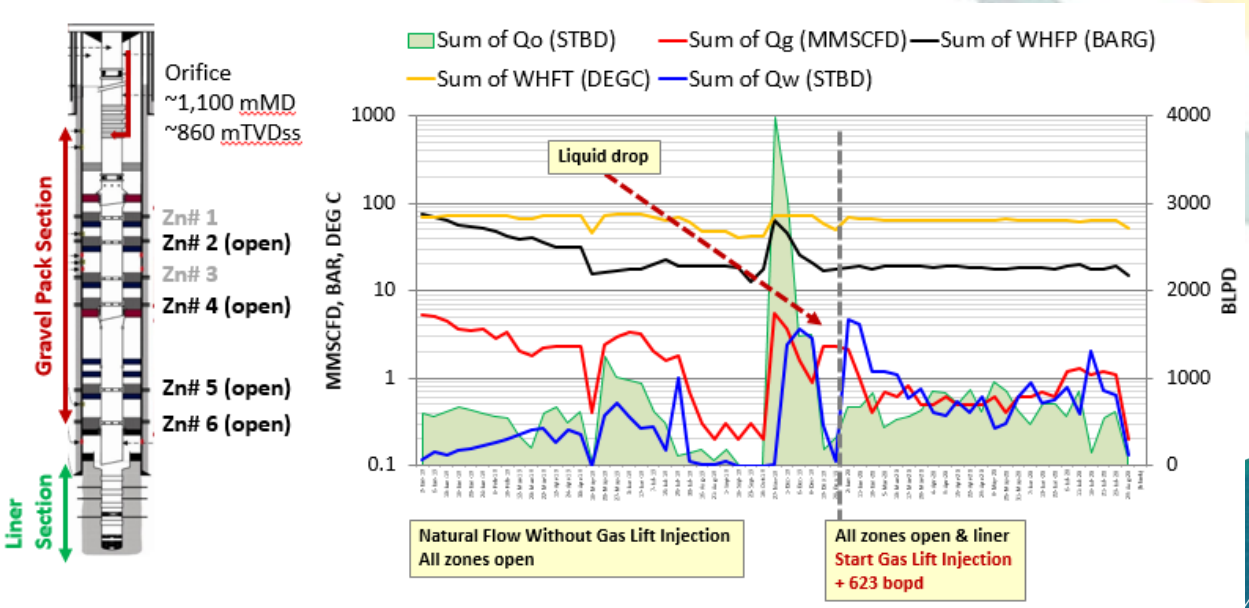


Figure 17. B-17 Well Diagram Illustration & Production Test

3 Result and Discussion

During 2019 – 2020, with all these efforts and optimizations, Bekapai success to slow down baseline decline rate in both oil and gas (Figure 18 & 19). For gas, decline rate in 2020 is lower than 2019, it's the same case for oil, we could maintain decline rate in 2020 at the lower level compared to 2019. Other than new wells, this baseline contribution is very significant for Bekapai production.

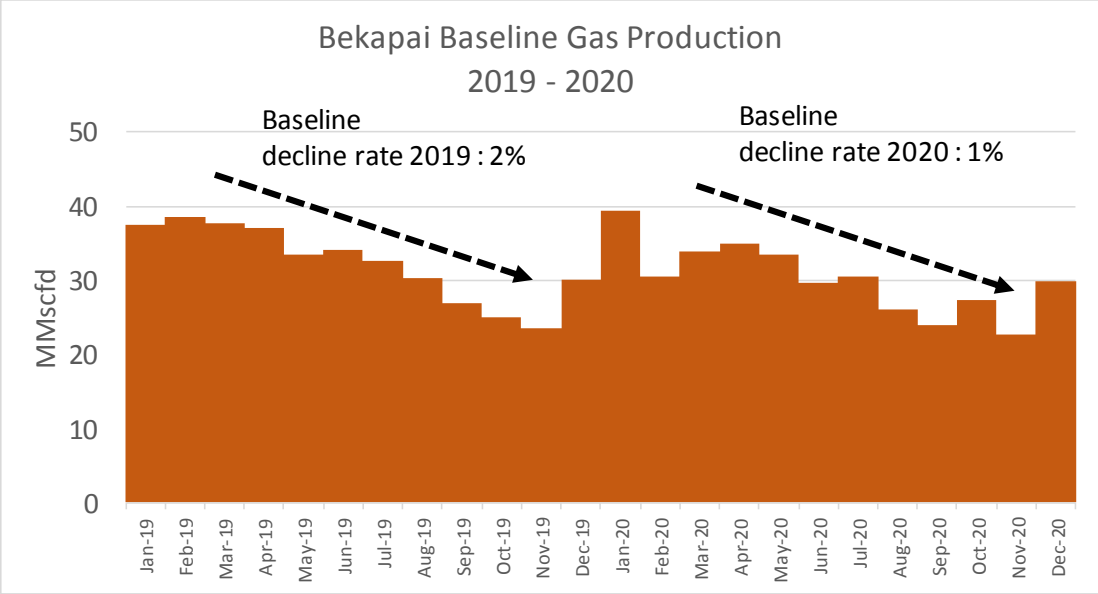


Figure 18. Bekapai Baseline Gas 2019 – 2020

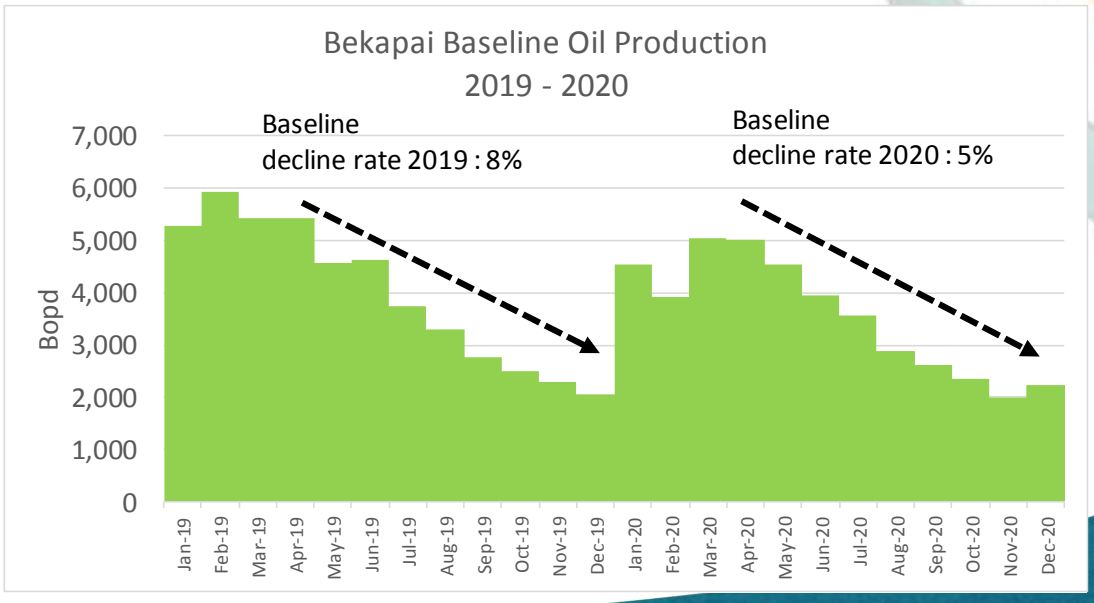


Figure 19. Bekapai Baseline Oil 2019 – 2020

4 Conclusion

Despite all subsurface challenges (depletion, sand prone & liquid loading issue) & surface limitation (aging surface facility), Bekapai team success to execute several optimization efforts and maintain baseline contribution at significant level. The success of these optimization efforts illustrates the value of continuous improvement and holistic approach between related entities in optimizing production from a mature oil and gas field.

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