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# A Success Strategy to Producing Thousands BOPD in Complex Pressure and Drive Mechanism Reservoir Conditions with Highly Uncertainty of Faulted Architecture Field in Rokan Block, Central Sumatera Basin

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**Abstract.** Depleted reservoir is becoming one of the challenges to be faced in mature oil field, especially when the pressure depletion is likely to fast comparing with similar oil field characteristics. TLN field (one of the prolific oil fields in the Rokan Block, Central Sumatera Basin) was one of successful example related to rapid reservoir pressure depletion. Pressure depletion in TLN field especially in MB block area was observed pretty rapid by latest pressure surveillance which caused by significant fluid withdrawn since 2003, which provoke to saturated reservoir conditions. Surprisingly, these depleted zones contributed 70% of total TLN field original oil in place and at its prime reservoir condition, MB block area was major contributor for oil production in TLN field particularly from PMT sands. This success story was accompanied to fulfill PT. Pertamina Hulu Rokan additional production and part of the 2021-2022 drilling campaign which two wells are proposed in TLN field. TLN field location approximately 30 km to the northwest of DRI field, which both operated by PT. Pertamina Hulu Rokan since August 2021.

To manage the dynamic and geological uncertainty of TLN field, which led to success of producing thousands of BOPD in 2020-2021 drilling campaign, we develop a certain strategy that suits in TLN field. From the geological aspect, we re-utilize the fault interpretation to mitigate havoc in development and execution stages using seismic reprocessing, seismic enhancement, and seismic attributes. As mentioned above the dynamic characteristics of TLN MB Block reservoirs are quietly challenging due to the pressure depletion led to the high gas oil ratio, which can be observed from drive mechanism plot of TLN Field. Likewise, the combination of weak water drive mechanism and solution gas drive that both works in TLN field is a challenge to be mitigate before well execution begin. With robust subsurface concept that applied when develop these two proposed wells in TLN field and combining with reservoir management strategy when well execution began such as, producing only from single sand and considering ESP design to be installed with gas separator, we successfully to produced additional oil gain of approximately ~2800 bopd and unlocking future potential strategy to develop MB block of TLN field, respectively due to low reservoir pressure.

As a lesson learned, we realized several strategies from geological aspect such as re-utilize the available seismic and generating seismic attribute similar like coherency to get higher resolution of fault plane location and fault continuity to mitigate the structural uncertainty in developing and further when execution phase begins. Moreover, a robust reservoir management is mandatory to overcome low pressure reservoir which can lead to high gas oil ratio must be managed appropriate to avoid gas production instead of oil production.

**Keyword(s):** Low Pressure Reservoir, Reservoir Management, Complex Fault Reservoir, Fault Uncertainty.



## INTRODUCTION

TLN field as one of many prolific oil fields in the Rokan Block is located approximately 30 km from DRI field, which both are operated by PT. Pertamina Hulu Rokan since August 2021 (figure 1a). Structurally, TLN field is divided into MB block and SE block. TLN field current production is coming from 34 wells from MB and SE block. History of these field was discovered in 1975 and start its production at 1997, whereupon reach its peak production on April 2004 with 9,766 BOPD. Based on the latest original oil in place of TLN field, it has RF value around 45%. MB block of TLN field held major contributor for oil production as well as the original oil in place than the SE block. Attic and up dip structural play are a proven trap system in TLN field as a structural geometry resulting from Sidingin Cluster faults. TLN field is a mature oil field which undergo pressure depletion in the productive oil reservoirs (SHP and PMT Fm). TLN field current reservoir pressure has significantly decreased to below the bubble point pressure. These pressure depletions provoke a high gas production in TLN field, which can be confirmed by the current Gas Oil Ratio (GOR) and solid evidence from TLN field drive mechanism. Besides applying GGR concept, we also manage an optimum and efficient modification of the combination between artificial lift and gas separator to mitigate excessive gas production and perforation interval for optimizing the oil gain. How we successfully applying integrated GGR concept and reservoir management efficiency to TLN field will further discussed in this paper.

### *Geological Settings of TLN Field*

The geological settings of TLN field are comprised of relay ramp structure trending in NE-SW direction. TLN field located in North Aman Trough, which one of several troughs in Central Sumatra Basin. Sidingin cluster main fault propagation in TLN field is separating this field into MB and SE blocks (figure 1). Structural trap structure of each block elongates in NW – SE direction and forming 3-way closure frameworks. A wide variety of proven petroleum play concept in Central Sumatra Basin dominantly formed as structural play, while the play concept of TLN field is classified as upthrown footwall block. The fault in each TLN field block is proven sealing mechanism instead of leaking, regarding the differences of fluid contact in each block.

### *Reservoir Conditions of TLN Field*

Productive reservoirs in TLN field are construct as a multi-layer sand from the SHP and PMT Fm with estimated porosity about 22% and permeability about 790 mD. Oil gravity in TLN field is about 33 API, which relatively belonging in light oil categories.  The existing well spacing in TLN field still has a wide distance regarding to mature field conditions with 45% RF value. TLN field reservoir current pressure has decreased to 794 psi and classified as a weak water drive and solution gas drive mechanism, which proven by the drive mechanism plot. Nonetheless, SHP reservoir drive mechanism classified as a strong water drive mechanism. PMT reservoir especially in lower part of PMT Fm has lie in saturated reservoir condition with the pressure already dropped below the bubble point pressure. Refer to the Anderson, J.S., 1991 it stated that the drainage areas are seldom circular and only limited when fully bounded by either sealing faults, stratigraphy, or by other wells. Considering the geological settings in TLN field, we concluded that the drainage radius from existing wells were controlled TLN structural framework and it proved by the formation evaluation resulf from the last two wells that drilled within this field. It is shown that the oil saturation still economically produced. **(Figure 2)**.

## METHODOLOGY

Integrated G&G and dynamic reservoir study are conducted as a strategy to maintain the oil production curve in TLN field above the plateu. Addition of two infill wells in TLN field are an outcome from these integrated GGR study which later contribute the thousands BOPD oil gain in TLN field. This integrated campaign was meant to focus on TLN MB block instead of SE block, because current pressure in MB block is still higher and promising than the SE block. To support G&G study, TLN field has available 3D seismic (acquisited at 1997) with total area of 342 $km^2$. Specifics bin size quality of these 3D seismic are 15m x 90m, 24 folds, and 23704 traces/$km^2$. TLN field 3D seismic have been reprocessed throughout year to improve structural interpretation, regarding to structural uncertainty. Dynamic reservoir data and engineering approach such as current pressure conditions, latest oil production, drive mechanism plot based on Ganesh Takur (1994), and modified ESP motor design to ensure ESP pump reliability and running life to handle high GOR wells. To sum up the major improvement and integrated GGR study for development strategy in TLN field are listed below:

1. Reprocessing TLN 3D seismic and running seismic attribute such as TFL (thinned fault likelihood) to obtain clearer fault interpretation for infill well candidacy locations, especially alongside the fault boundary.
2. Generate current static property map for the prolific reservoirs in TLN field (PMT reservoir)
3. Design ESP to overcome depleted pressure reservoir below bubble point pressure.

### *1. 3D Seismic Reprocessing and Seismic Attributes of TLN Field*

Structural uncertainty in TLN field remains a big question for development strategy yet opportunities. Further seismic analysis is mandatory to acknowledge more robust fault plane in TLN field, or at least come up near the actual location. Before we are running a seismic attribute, determine attic location, and placing infill well location to attack alongside the fault plane, seismic reprocessing such as phase rotation was conducted to configure the seismic volume perpendicular with existing fault location about two times than the bin size. From the seismic reprocessing output we obtained fault uncertainty envelope location approximately more western than the interpretated main fault of TLN field. Honoring the fault uncertainty envelope, we managed to optimized sand target location for the proposed infill wells to ensure it drilled safely and maximize foot wall portion which oil pay from SHP and PMT Fm located, by using latest existing fault marker locations such as repeat section interval and averagely coming high from sand markers in latest TLN well which is indicating footwall and hanging wall geometry especially near the fault boundary.

Regarding to the seismic quality of TLN field are best fitted in structural interpretation, we decided to run seismic attribute to clarify existing fault continuity and precise attic/updip location for development plan in TLN field. This seismic attribute called as Thinned Fault Likelihood (TFL) which using the concept of power of semblance with range value from 0 -1. TFL attribute aim to provide delineation of either faults and fractures in an area, this attribute algorithm reads a fault or fracture dips to identify the likelihood, however there is still a pitfall in this newly attribute. Brief workflow from G&G analysis until we came up with updated fault uncertainty location and attic/updip near fault boundary portion are shown in Figure 3.

### *2. Static Reservoir Property Map from Current Condition*

To provide more robust estimation of current oil column distribution in TLN field, we managed to generate a Net Pay map. This map aims to visualize current oil thickness as a function from volume of shale (Vsh), porosity, oil saturation (So), and current fluid contact. Petrophysical aspects are considered to generate these maps, so petrophysical cut off analysis was conducted to define cut off value from VSH, Porosity, and SW on PMT reservoir. VSH cut off is defined by cross plot between Porosity log (y-axis) and VSH log (x-axis) which inform the data clustered majority by high VSH are having a high SW too, filtered by SW on z-axis, we observed that oil accumulated in reservoirs with VSH less than 0.5. To define Porosity cut off, cross plot between Porosity log (y-axis) and VSH log (x-axis) is used again. We plot the VSH cut off on these cross plots, then we observed the clustered data/reservoir intervals which be able to store oil by means of Porosity, which indicated by the data clustered on low SW (z-axis). While to define SW cut off, we use fractional flow curve which is the SW derived from Simandoux equation. From the fractional flow curve, we obtain the SWE cut off at 0.575, which equal to watercut value as much as 0.995. As a summary from petrophysical cut off analysis, we summed up that cut off for porosity is 0.12, VSH is 0.5, and SW is 0.575. Net Pay maps were generated for each targeted PMT sands with control from lowest known (LKO) oil fluid contact which interpreted from the latest producing intervals. With combination Vsh map, Isoporosity map, So map, and bounded by current fluid contact, then calculated to obtain Net Pay map. Figure 4 is showing current Net Pay in PMT reservoir are quietly promising, especially when we look at the attic portion near the fault boundary showing enormous current hydrocarbon column.

### *3. ESP Pump Design*

Drive mechanism of an oil field held a important consideration to be notice, with knowing how the reservoir behave in an oil field forth govern how we manage and arrange reservoir management strategy. Reservoirs in TLN field behave differently from its drive mechanism, SHP reservoir tend to have strong water drive, whereas PMT reservoir well known as saturated reservoir tend to have current pressure below the bubble point pressure. It is concluded that we were unable to commingle production between these two-type reservoir. By having the pressure latest performance from TLN Field we decided to produce lower sand at the beginning then will adopt bottom-up scenario to produce the upper part of this well with 3.5” tubing size.

This well were expect will have maximum rate about 4000 bfpd and predicted will produce a quite amount of gas hence we prepared gas separator installed on the ESP string line. These two wells of TLN field will be produce with P23-66STGs/GS/GSB3DB/125HP and additional gas peculator to avoid gas lock on the ESP.

## Well Execution Challenge

After we came up with two additional infill wells in TLN field (well A and well B), we planned the trajectory to attack oil pay zone from upper and lower PMT reservoir. To maximize oil pay zone which well-known located at attic/updip portion in footwall block (near the fault boundary), we planned and successfully to drill alongside the fault boundary in TLN MB block. Sequentially, well B was drilled first. Recalling to fault uncertainty, we are pretty sure there is no potential of drilling hazard when well B was proposed, since we already honour the first fault uncertainty envelope. During well B execution job, it run into some drilling issues which led to unsuccessful obtaining upper PMT reservoir. Instead to drill TD in foot wall block, well B trajectory was entering hanging wall block and running into loss circulation at upper PMT reservoir. Backup plan for geosteering job was conduct in order to get back in the foot wall block to recover at least the lower PMT reservoir. Turns out the geosteering job was succeeded to recover lower

PMT reservoir in foot wall block. From well B we obtain updated fault marker location, we updated the fault location by tie in the fault marker from LWD log. Very unfortunate due to the high angle well borehole we were unable to run any production logging tools due to the deviation constraint. With robust and optimized available data update from well B, well A did not encounter any drilling problem even though it has high inclination. Well A consistently drilled in foot wall block of TLN MB block and success penetrating all targeted reservoir. Figure 6 shows the pre-drill and post drill design for both wells. Regarding to the dynamic reservoir conditions in PMT reservoirs which previously taken from surrounding swab test data and SBHP surveillance test, we already have expected an excessive gas to be produced due to low-pressure from PMT reservoir. To mitigate excessive gas production, modified Electric Submergible Pump (ESP) was installed with gas separator to counter the gas production from borehole. The pressure from casing was observed in very high pressure, and impacted the gas lock onto the ESP.

## RESULTS AND CONCLUSIONS

From the drilling result for these two infill wells are showing astonishing result compared to property prognosis.Well A and well B prognosed property such as HPT about 11 ft and 18 ft, net pay thickness 88 ft and 123 ft. The actual net pay of well B likely not significantly higher than the prognose, it only 167 ft with actual HPT of 18.9 ft. From updated marker depth, which relatively coming high is indicating another potential distribution of closure portion ini TLN Field for further development strategy. Perforation job must be executed in efficient, so we decided to use high graded perforation strategy to choose best sands interval to be perforated, because the whole sands in TLN field can't be produced commingle due to depleted pressure. Bottom-up strategy such as opening lower pressure first to optimize production curve in TLN field. These two wells were produced using 3.5 tubing and modified ESP with gas separator installed and planned to produce with 2000 bfpd production rate to mitigate gas production during POP period. Peculator was installed in annulus to recover excessive gas production and ensure no gas production affecting the back pressure inside the ESP motor (Figure 7). This engineering-based success to produced oil form Well B. Although well B run into drilling and POP issues, it is resulting remarkable initial production as of 2068 BOPD and well A initial production of 770 BOPD with 0% WC from both wells.

We concluded that : **(1)** Robust fault interpretation and enhancement are mandatory as the key role to define attic/updip closure position and size to ensuring the drilling program run as planned, **(2)** Geosteering is mandatory to execute well with high deviation angle and high uncertainty of structural distribution, **(3)** Optimum artificial lift tools selection and high-grade perforation strategy play a major role to mitigate pressure differentiation in multiple sands reservoir, **(4)** Further collaboration and comprehensive study both to learn the static heterogeneous reservoir and how the dynamic drainage radius interpretation flow are generated were required to put additional producer and injector placement to maintain pressure depletion and improve recovery factor in TLN MB block .

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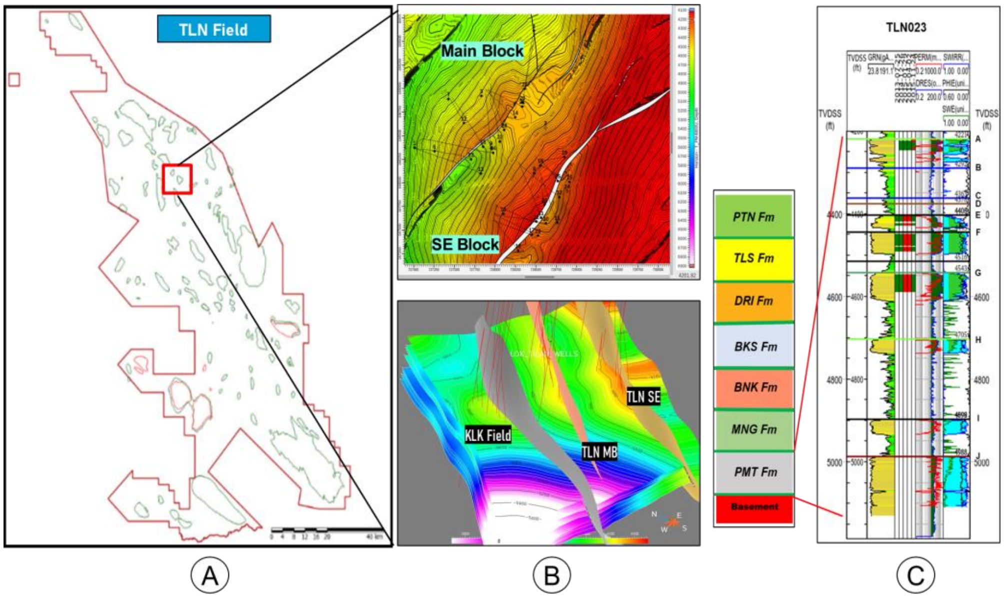
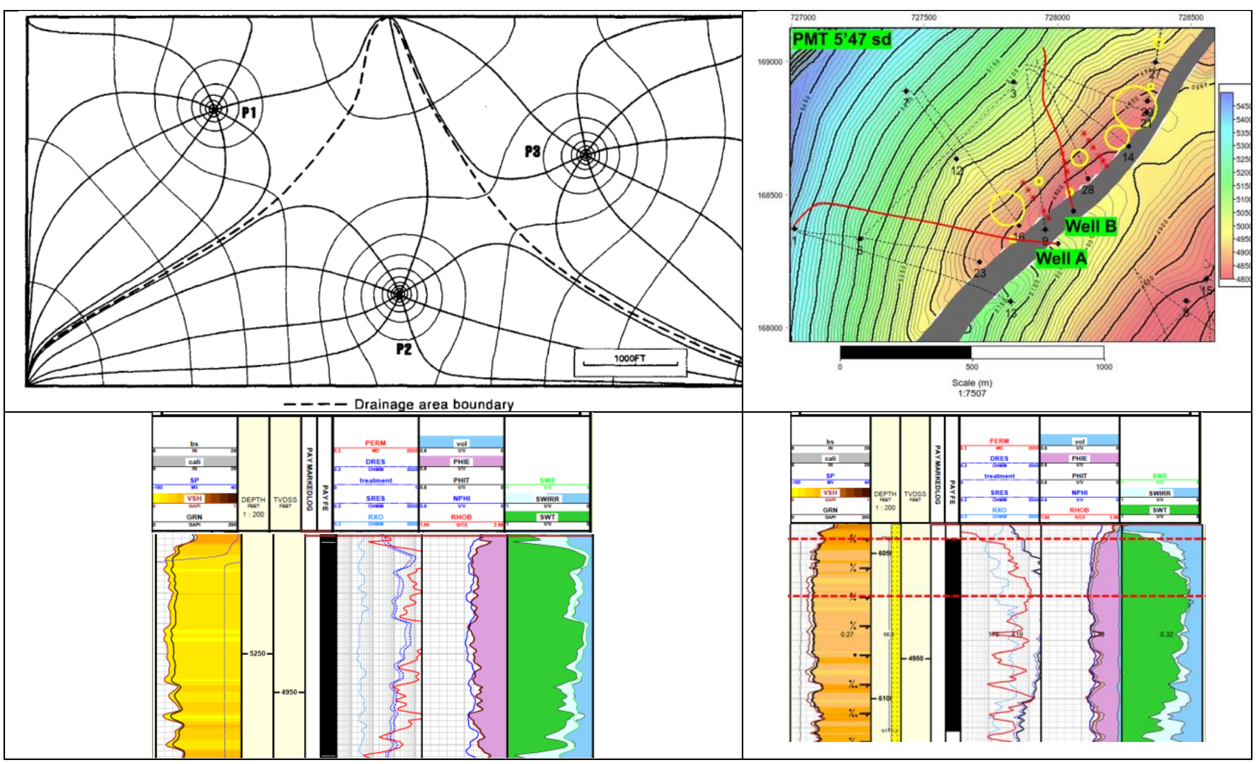



Figure 1. Regional settings and the location of TLN field in Rokan Block, Central Sumatra Basin (figure 1a); TLN field structural framework is showing it separated into MB and SE block and KLK Field in NW direction with majority structure has likelihood with TLN Field (figure1b); SHP and PMT reservoir in TLN Field (Heidrick and Aulia,1993) (figure 1c).



| TLN 14 Drilled 2003 | TLN 33 Drilled 2021 |
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Figure 2. Drainage radius map from PMT 5’47 sd (lower PMT Fm), it shows the visualization of current oil production from this sand has not wide enough to affect the oil production from additional infill wells which targeted at the same sand both based on conventional or structural framework analysis boundary.

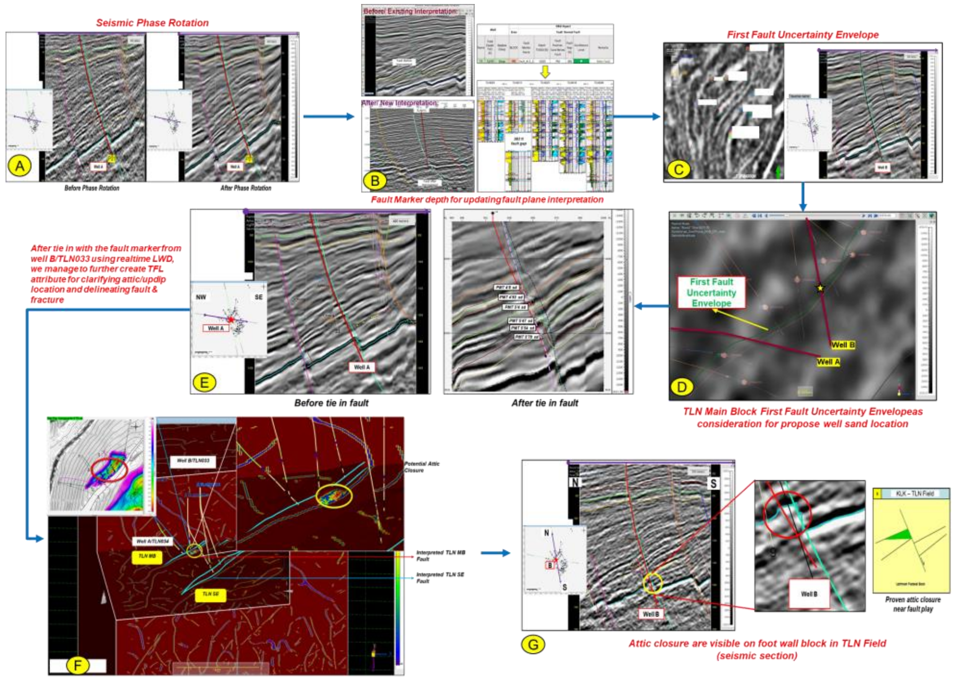


Figure 3. Figure 3(a) – 3(g) are showing workflow of G&G analysis to overcome the fault uncertainty location and attic/updip portion in TLN MB Block. Seismic reprocessing choosed to enhance structural visualization for robust interpretation, then updating fault marker using latest drilling data. First fault envelope uncertainty with approximately 30 meters away to the west from existing interpreted main fault (so do the sand target). After well B drilled cross the fault, we update robust fault plane location by tie in the fault marker. As supplementary we generate TFL attribute to delineate major fault in TLN field.

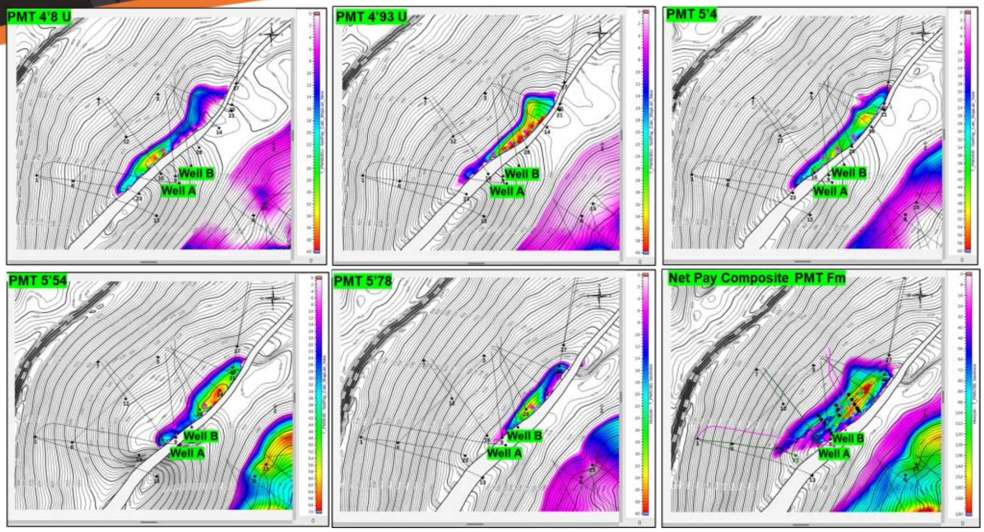


Figure 4. Montage of Net Pay maps from upper and lower PMT reservoir in TLN field. From the current oil pay thickness that already been cut off by petrophysical properties still showing great opportunities of remaining net oil column in TLN MB block, especially near the fault boundary of attic/updip portion. Color grading only filled inside the current fluid contact.

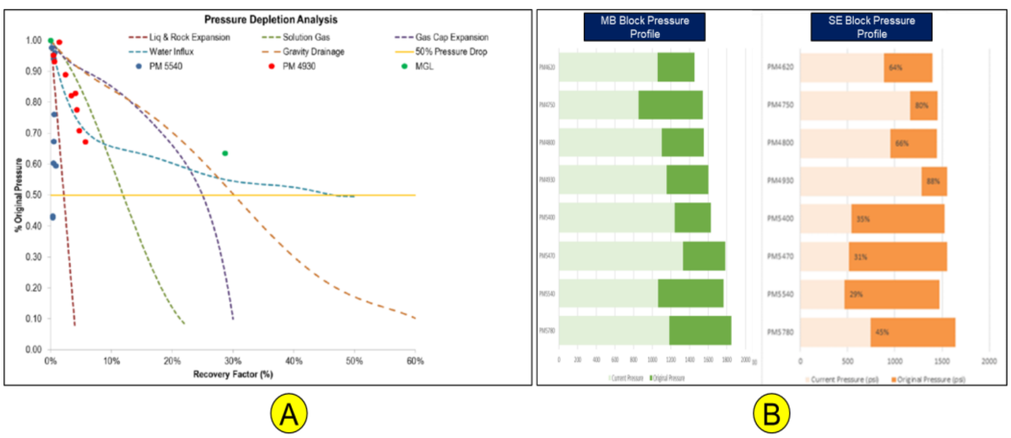


Figure 5. Figure 5(a) showing drive mechanism plot from PMT reservoir shown by red & blue dots (solution gas drive) and SHP reservoir shown by green dots (strong water drive). Figure 5(b) showing pressure profile from TLN MB and SE block, notice that in MB block had higher pressure than the SE block.

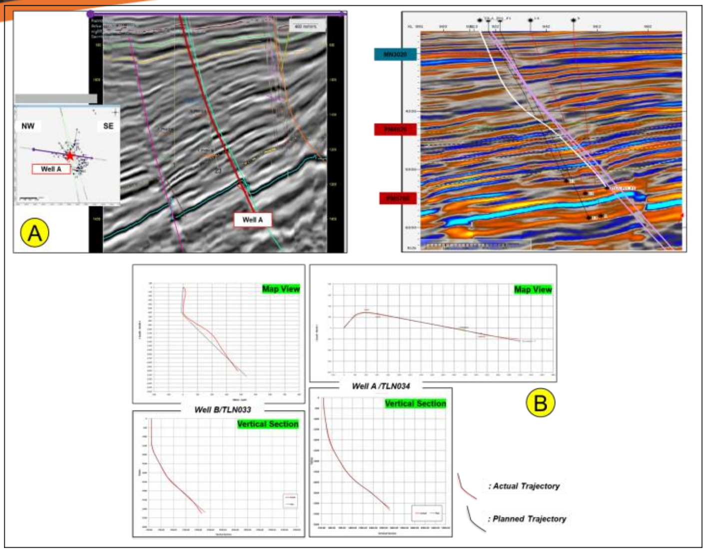


Figure 6. Figure 6(a) is showing the prognosis well A trajectory (left) and the actual updated trajectory in execution job of well A (right). Figure 6(b) is showing comparison between the actual and planned trajectory of well A and well B from Map and Vertical point of view.

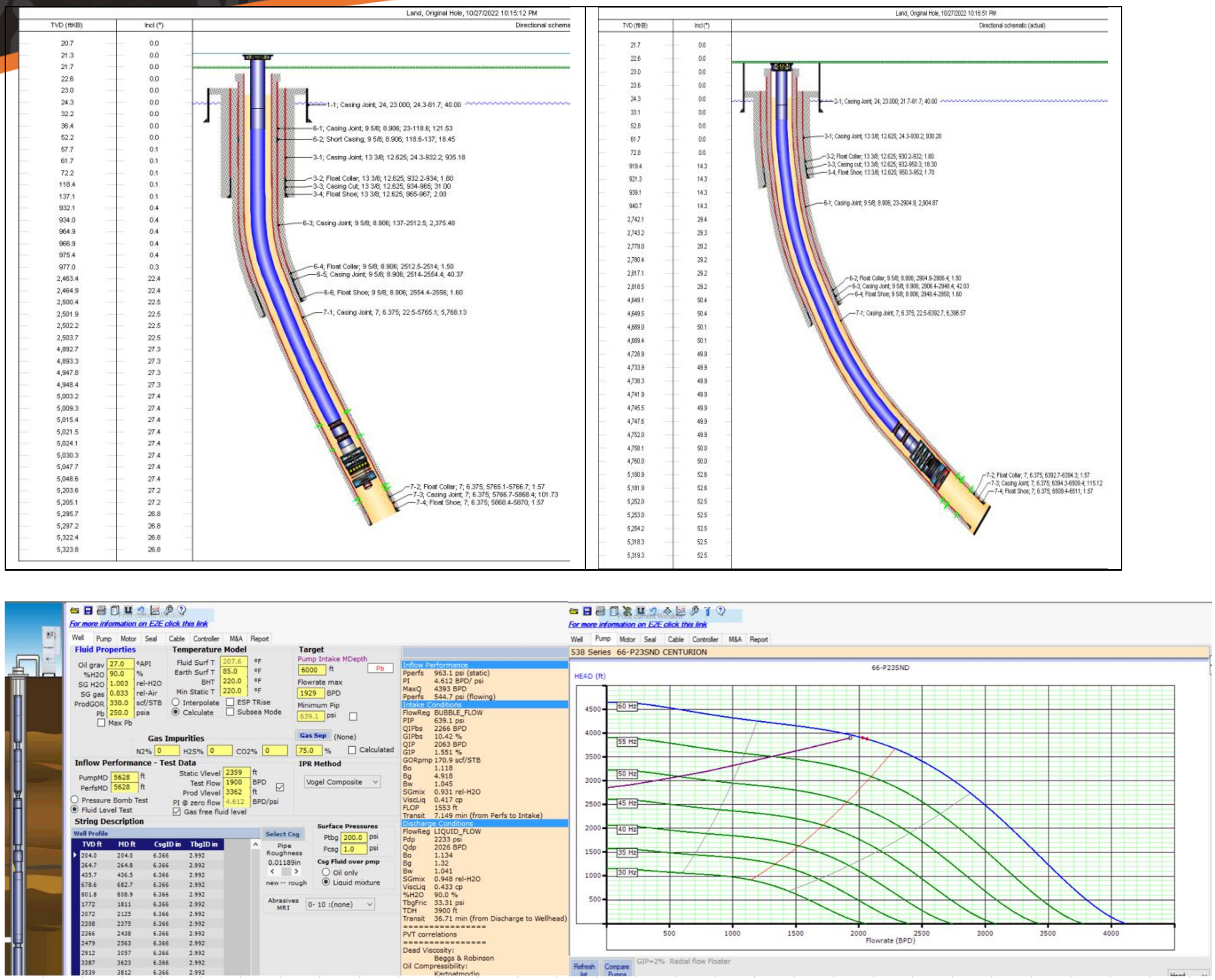


Figure 7. Figure 7 shown the Completion and ESP design from TLN Field

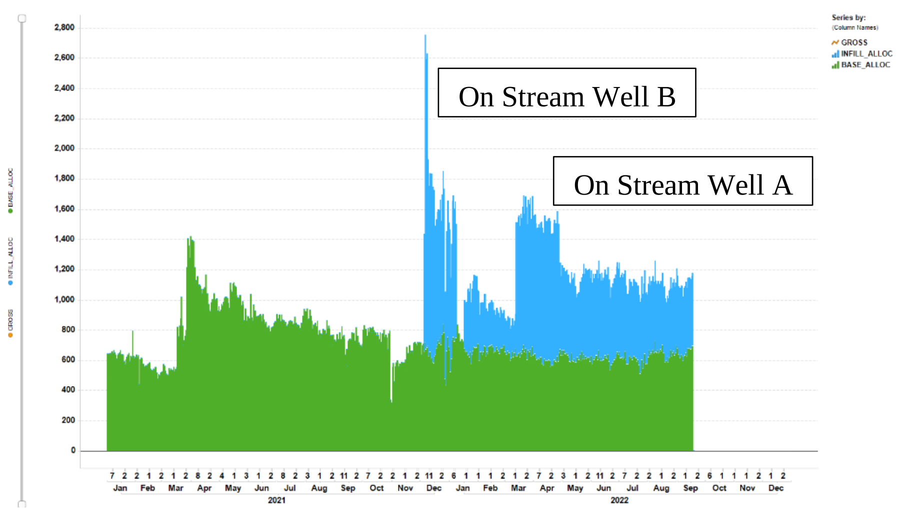


Figure 8. Figure 8 shown the production Performance from TLN Field