X BROWN FIELD SAND MANAGEMENT: ACOUSTIC SAND MONITORING

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***Abstract*—X field is a 40 years old oilfield with a history of sand production problem. The purpose of this paper was to propose a sand management strategy for Field X to mitigate sand production while maintaining an acceptable rate of production through choke size optimization using acoustic sand monitoring. Acoustic sand monitoring was used to calculate the sand rate of selected candidate wells. Based on the sand rate obtained from the acoustic sand monitoring, choke optimization for each wells are suggested. Only well B58S were suggested to be bean down in choke size while other well are suggested to be increased its choke size**

Keywords— Acoustic sand monitoring, choke optimization, surface sand management.

I. INTRODUCTION

Field X has been producing for nearly 40 years with extensive sand production history (Vincy, Basri, and Arifin, 2013). Sand management can be regarded as an operating concept where production is regulated through monitoring, controlling the pressures of well, fluid production rates and the influx of sand (Tronvol, Dusseault, Sanfilipo and Santarelli, 2001). Uncontrolled sand production can lead to destruction of surface equipment such as pipelines, separator or choke. The most effective sand management strategy requires an integrated approach which can lead to significant increase in production with minimal sand problem.

One of the main problem in sand management is deciding the optimum choke size where the wells are producing at optimum productivity rate with no or minimal sand production. Haugsdal (2007) said that producing at lower rates means a lower drawdown which lead to low sand production but since there is a demand that must be cater for the client so producing at such low rates is unacceptable and is consider as counter-productive.

II. METHODOLOGY

A. *Materials or Data*

Acoustic Sand Data – The acoustic signal of the sand when the particle passes through pipeline. The sound generated are detected by a microphone transducer that are placed at an appropriate location (preferably at pipe bent)

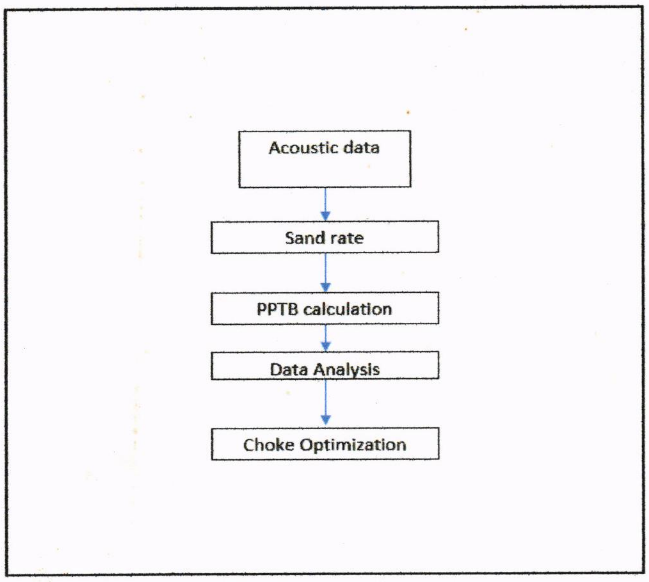

Fig 1: The Overall Methodology

III. RESULTS AND DISCUSSION

A. *Sand Analysis*

B042

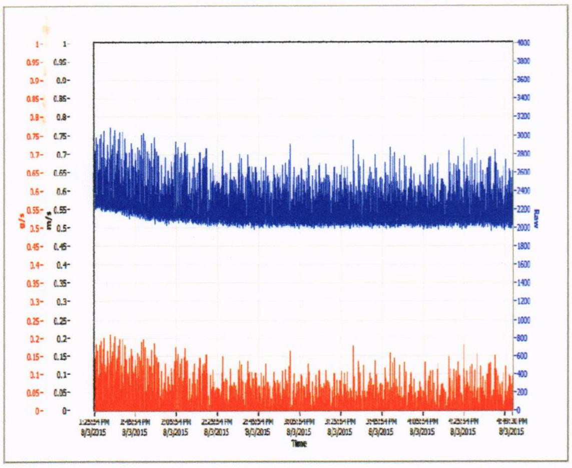

Fig 2: Sand Acoustic trend for well B042

Table 1: Sand and raw acoustic summary

	Maximum	Minimum	Average	Total
Sand	0.208 g/s	0 g/s	0.013 g/s	0.158 kg
Raw	3078	1964	2206	

Table 2: Well sand analysis summary

Duration	3.5 Hours
Choke Setting	58/64
Type of well	Oil
Mix Flow Velocity	4.99 m/s
Total sand during total time	0.158 kg
Sand rate	45.14 g/hr

Figure 2 shows the sand and acoustic trend for well B42.From the trend of the sand and acoustic signal shows that this well is stable during the monitoring period. For this well the maximum sand produced was around 0.208 g/s and averaged around 0.013 g/s. The sand rate calculated by the software shows that this well produced 45.14 g/hr. Even when the well is producing with large choke size, the sand produced is still relatively small.

B063L

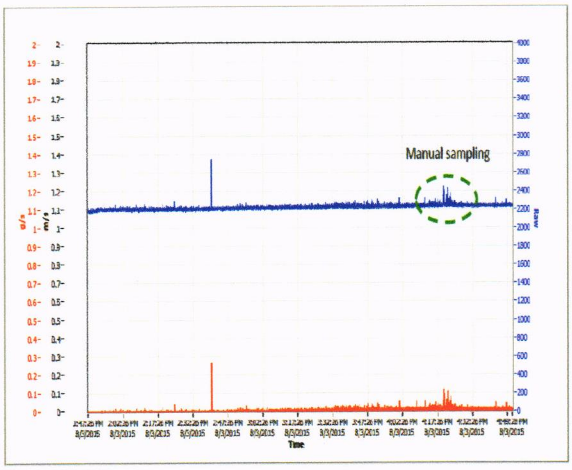

Fig 3: Sand Acoustic trend for well B042

Table 3: Sand and raw acoustic summary for well B042

	Maximum	Minimum	Average	Total
Sand	0.263 g/s	0 g/s	0.03 g/s	0.032 kg
Raw	2735	2162	2219	

Table 4: Well sand analysis summary for well B42

Duration	3 Hours
Choke Setting	28/64
Type of well	Oil
Mix Flow Velocity	2.45 m/s
Total sand during total time	0.032 kg
Sand rate	10.67 g/hr

Figure 3 shows the result of acoustic trend for well B63. From the figure it can be seen that the sand production increases as time increases. The maximum sand throughout the monitoring period found out to be at 0.263 g/s and average around 0.03 g/s. The little difference between maximum and average sand produce shows that the well are stable throughout the monitoring period. The sand produced totaled at 0.032 kg. The small choke size and stable well may contribute why only a significant amount of sand produced.

B068S

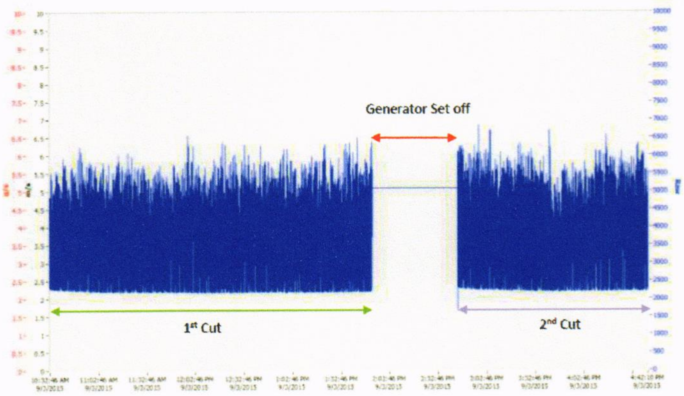

Figure 4: Sand Acoustic trend for well B068S

Table 5: Well sand analysis summary well B068S

Well No	B068S
Duration	5.3 Hours
Choke Setting	32/64
Type of well	Oil
Mix Flow Velocity	3.31 m/s
Total sand during total time	0.62 kg
Sand rate	116.98 kg/hr

Figure 4 shows the sand trend for well B68. The reason why the trend are divided into two cut is because the generator set off during the monitoring period. For the basis of calculation the sand calculation are divided into 2 parts. The total sand for both cut will be summed and used for the calculation as single value. The sand produced for the total time was 0.62 kg

B068S 1st Cut

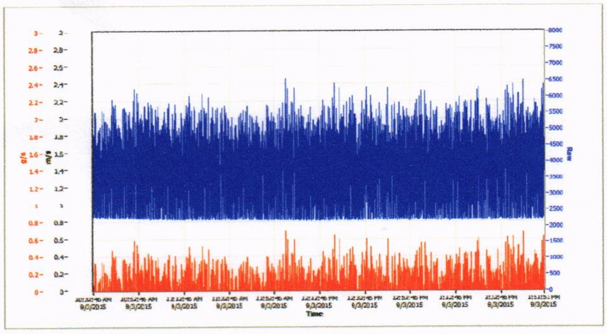

Fig 5: Sand Acoustic trend for well B068S 1st Cut

Table 6: Sand and raw acoustic summary for well B068S 1st Cut

	Maximum	Minimum	Average	Total
Sand	0.69 g/s	0 g/s	0.028 g/s	0.329 kg
Raw	6548	2153	3857	

Table 7: Well sand analysis summary well B068S 1st Cut

Well No	B0068S
Duration	3.3 Hours
Choke Setting	32/64
Type of well	Oil
Mix Flow Velocity	3.31 m/s
Total sand during total time	0.329 kg
Sand rate	99.69 g/hr

Figure 5 shows the sand trend for the first cut of B68S. The maximum sand produced was at 0.69 g/s and average sand produced was at 0.028 g/s. The wide range between maximum sand and average sand can be justified by observing the sand trend, significant hairy spikes was produced throughout the monitoring. The hairy spikes may be resulted from high flow velocity during that time or during that specific time the sand produced was relatively high.

BO68S-2nd Cut

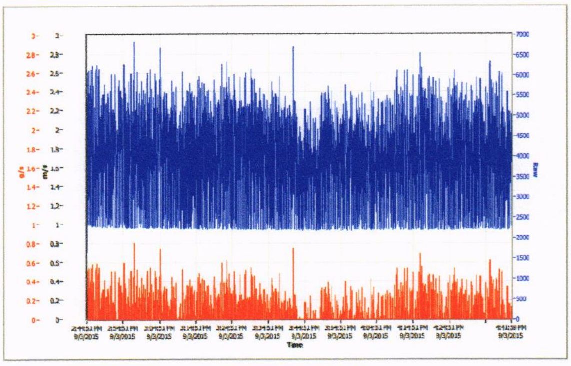

Figure 6: Sand Acoustic trend for well B068S 2nd Cut

Table 8: Sand and raw acoustic summary for well B068S 2nd Cut

	Maximum	Minimum	Average	Total
Sand	0.798 g/s	0 g/s	0.041 g/s	0.291 kg
Raw	6840	1665	3964	

Table 9: Well sand analysis summary for well B068S 2nd Cut

Duration	2 Hours
Choke Setting	32/64
Type of well	Oil
Mix Flow Velocity	3.31 m/s
Total sand during total time	0.291 kg
Sand rate	145.5 g/hr

Figure 6 shows the 2nd cut of sand trend for well B68. The maximum sand produced for this well during the monitoring period was 0.798 g/s and average sand produced was 0.041 g/s. Constant hairy spikes can be observed for this well means high sand production throughout the monitoring period which justify the value for high sand rate of 145.5 g/hr. Since the well is only monitored for only 2 hours the total sand produced is only 0.291 kg smaller compared the value of 1st cut even though the 2nd cut has higher sand rate.

B66L

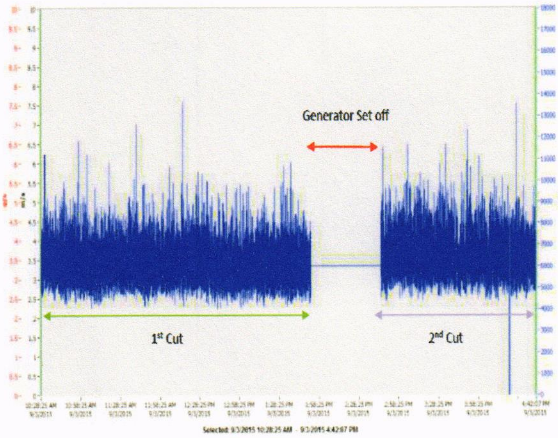

Fig 7: Sand Acoustic trend for well B066L

Table 10: Well sand analysis summary for well B066L

Well No	B066L
Duration	5.3 Hours
Choke Setting	32/64
Type of well	Oil
Mix Flow Velocity	7.53 m/s
Total sand during total time	0.674 kg
Sand rate	127.16 kg/hr

Figure 7 represent the sand trend for well B66L. Generator setoff causes the reading divided into two. For the sake of calculation the reading are divided into 2 parts.

B66L – 1st Cut

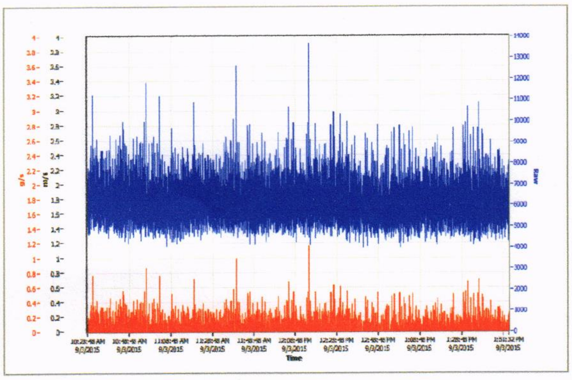

Fig 8: Sand Acoustic trend for well B066L 1st cut

Table 11: Sand and raw acoustic summary for well B066L 1st cut

	Maximum	Minimum	Average	Total
Sand	1.157 g/s	0 g/s	0.027 g/s	0.326 kg
Raw	13670	4012	6064	

Table 12: Well sand analysis summary for well B066L

Duration	3.3 Hours
Choke Setting	34/64
Type of well	Oil
Mix Flow Velocity	7.53 m/s
Total sand during total time	0.326 kg
Sand rate	98.78 g/hr

Figure 8 shows the first cut of well B66L. By looking at the sand trend only few significant spikes found which maybe causes by large grain size of sand. The maximum value for sand was 1.157 g/s and the average sand was only 0.027 g/s. The large difference in maximum and minimum sand produced is because occasionally large grain size hits the wall of the pipe causing high acoustic raw reading. The sand rate for this well was 98.78 g/hr

B66L 2nd Cut

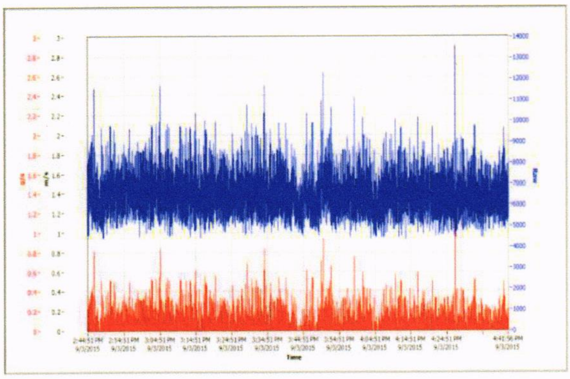

Fig 9: Sand Acoustic trend for well B066L 2nd cut

Table 13: Sand and raw acoustic summary for well B066L 2nd cut

	Maximum	Minimum	Average	Total
Sand	1.139 g/s	0 g/s	0.049 g/s	0.348 kg
Raw	13560	0	6389	

Table 14: Well sand analysis summary for well B066L

Duration	2 Hours
Choke Setting	34/64
Type of well	Oil
Mix Flow Velocity	7.53 m/s
Total sand during total time	0.348 kg
Sand rate	174 g/hr

Figure 9 shows the 2nd cut for sand trend of well B66L. By looking at the spikes trend significant amount of spikes can be observed and there are few of them are rather high. This is the reason why the maximum and average value of sand per second are largely gapped which is 1.139 g/s and 0.049 g/s respectively. The well have relatively high sand rate of 174 g/hr but smaller total sand compared to the first cut which is because for the 2nd cut the well is only monitored for 2 hours while the 1st cut well are monitored for about 3.3 hours.

B063S

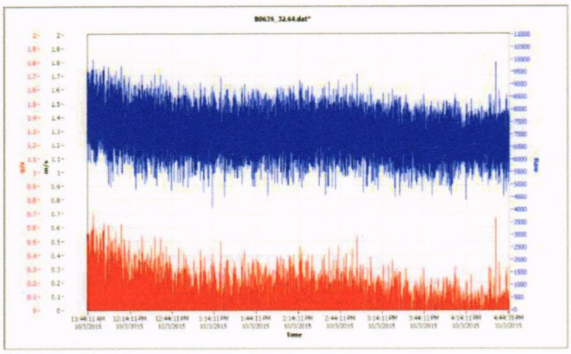

Fig 10: Sand Acoustic trend for well B063S

Table 15: Sand and raw acoustic summary for well B063S

	Maximum	Minimum	Average	Total
Sand	0.696 g/s	0 g/s	0.033 g/s	0.603 kg
Raw	10020	1300	7015	

Table 16: Well sand analysis summary for well B063S

Duration	5 Hours
Choke Setting	32/64
Type of well	Oil
Mix Flow Velocity	4.55 m/s
Total sand during total time	0.603 kg
Sand rate	120.6 g/hr

Figure 10 shows the sand trend for well B63S. By observing the sand trend it can be seen the sand production decreases as time progresses. The maximum sand produced was observed occurred at the initial phase of the monitoring period. The maximum sand produced was 0.696 g/s and average around 0.033 g/s.

B058S

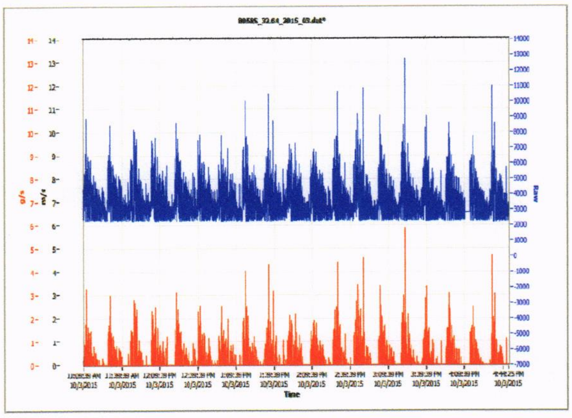

Fig 11: Sand Acoustic trend for well B058S

Table 17: Sand and raw acoustic summary for well B058S

	Maximum	Minimum	Average	Total
Sand	5.835 g/s	0 g/s	0.106 g/s	2.133 kg
Raw	12710	2235	3467	

Table 18: Well sand analysis summary for well B058S

Duration	5.7 Hours
Choke Setting	32/64
Type of well	Oil
Mix Flow Velocity	1.99 m/s
Total sand during total time	2.133 kg
Sand rate	374.21 g/hr

Figure 11 shows the sand trend for well B58. By looking at the pattern the well might be slugging. This causes flow velocity to be invalid and sometimes the sand grain to be hitting the well at high momentum causing invalid spikes. This well produced more sand rate compared to other well which is 374.21 g/hr.

B. *PPTB Calculation*

The Pounds per thousand barrel can be calculated with the total sand value and the welltest data. Example below shows how PPTB calculation are done

Example of calculation B42S

$$PPTB = \left(\left(\frac{m}{t}\right) X\ 24\right) X \left(\frac{1000}{x+y+z}\right) X\ 2.205$$

x = 230.0 (bbl/day)

y = 686 (bbl/day)

z = 213.77 (bbl/day)

t = 3.5 (hours)

m = 0.158 (Kg)

=

$$\left(\left(\frac{0.158\ KG}{3.5\ hr}\right) X\ 24\right) X \left(\frac{1000}{230\frac{bbl}{day}+586\ bbl/d+213.77 bbl/d}\right) X\ 2.205$$

= 1.0834 x 0.8851 x 2.205

= 2.1144 PPTB

C. *PPTB for Every Well*

Table 19: Summary of PPTB

	Well Test Data				Sand Data			
Well	**Oil (bbl/d)**	**Gas (Mscf/d)**	**Water (bbl/d)**	**Mix Flow Velocity**	**Hours**	**Total Sand (Kg)**	**Sand Rate (g/hr)**	**PPTB**
B42S	230.0	1282.0	686.0	4.99	3.5	0.158	45.14	2.11
B63L	136.0	468.0	652.0	2.45	3.0	0.032	10.67	0.65
B68S	335.5	1100.0	274.0	3.31	5.3	0.620	116.9	7.80
B66L	212.0	2043.0	2099.0	7.53	5.3	0.674	127.16	2.53
B63S	160.8	1231.0	643.2	4.55	5.0	0.603	120.60	6.32
B58S	505.0	625.0	326.0	1.99	5.7	2.133	374.21	21.06

D. *Choke Optimization*

Table 20: Choke Optimization

Well	**PPTB**	**Current Choke Size**	**Recommendation**
B42S	2.11	58	Minimal sand found. Recommend to increase choke
B63L	0.65	28	Minimal sand found. Recommend to increase choke
B68S	7.80	32	Well should be further monitored if there is no increase in sand the

			choke size should be increase
B66L	2.53	34	Minimal sand found. Recommend to increase choke
B63S	6.32	32	Well should be further monitored if there is no increase in sand the choke size should be increase
B58S	21.06	32	The sand exceed the maximum allowable sand limit. Choke should be decrease and the well should be monitored

IV. Conclusion

From the results it can be observed that sand rate and monitoring period affected the total sand per period. Higher total sand will resulted in higher PPTB. As the sand rate increases the PPTB also increases given a constant time of monitoring period. Well B063L that the lowest PPTB and also possesses the smallest amount of sand rate which is 10.67 g/hr which further justify above theory that sand rate and PPTB have linear relationship.

Choke Optimization was made based on the results of pound per thousand barrel. The well that have the littlest amount of sand also had its choke setting at the smallest compared to other wells. The small amount of sand is because of the lower choke size that causes lower drawdown pressure. If the well operates under the critical drawdown pressure no massive sand production will be seen. Based on the field standard operating guideline, any well that producing under 15 PPTB of sand should be recommended to be bean up. The only well that is suggested to be bean down is well B58S while other are suggested to be bean up.

V. Recommendation

- To improve the accuracy of sand management decision making it is best to combine with other sand monitoring tools such as spot sampling
- Real-time well test data can help to improve the sand rate calculation since the well flow regime is ever changing. So by using a real time well test data the mix flow velocity is representative of the current well flow

VI. Acknowledgment

I would like to express my sincere gratitude to my supervisor Dr Erfan Mohammadian who have been guiding me throughout my project. I also would like to thank PETRONAS Carigali Sabah Operation who helped me with providing the information that I needed.

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