The optimal lateral length and well pad size for maximising recoverable reserves of shale gas in northern England.

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ReFINE RESEARCHING FRACKING
M4ShaleGas Measuring, Monitoring, Mitigating, Managing the Environmental Impact of Shale Gas

1. Introduction

- With the success of shale gas in the US[1] other more densely populated countries, including several in Europe, for example England, have begun exploration for shale gas [2] (Figure 1).
- Previous studies[3] have shown that infrastructure may limit the carrying capacity for shale gas development, however the factors impacting its optimal strategy have not yet been explored.
- **Aim of this study:** To determine the optimal lateral length that limit disruption on the surface while maximising technically recoverable reserves for the Bowland Shale (UK).

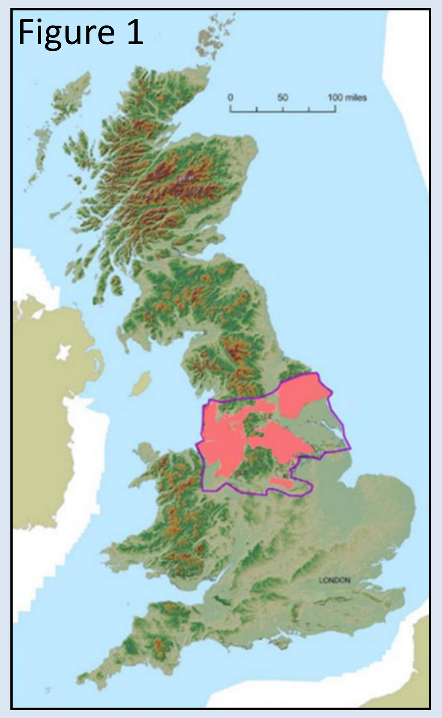
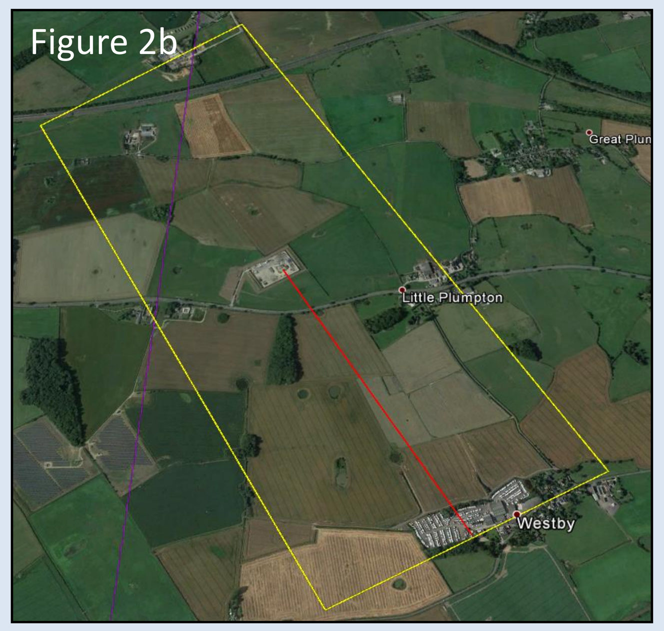


Figure 1: The area outlined in purple indicates the location of the Bowland-Hodder Shale in Central Britain. The prospective areas for shale gas are highlighted in pink[1].

2. Approach

This study considered two approaches to assess the relationship between technically recoverable reserve estimates and the carrying capacity of the surface. The first is empirically derived, whereas the second stochastically.



Using values from Table 1 for a single-well pad located over the Bowland Shale the below equations were empirically calculated.

- The direct surface footprint (Figure 2a):

$$S_f = W_a + L_a L_n \quad \text{(i)}$$

- The subsurface footprint (Figure 2b) of any well pad can be defined as:

$$S_{sf} = (L_l L_w)\, L_n \quad \text{(ii)}$$

- The indirect surface footprint:

$$I_f = (2B)^2 \quad \text{(iii)}$$

- Technically recoverable reserves:

$$T = \theta \varphi R \quad \text{(iv)}$$

Figure 2a: The measured direct surface footprint (S_f) for the Preston New Road site in Lancashire in July 2017 was 41437 m^2. Figure 2b: An indication of the extent of the indirect subsurface footprint (S_{sf}) for the Preston New Road site with a 1250 m lateral.

- Carrying capacity (θ): has been determined by assessing how many well pads with their associated setbacks (B) and laterals (L_l) can be located within 20 license blocks located over the Bowland Shale, without overlap or disruption of the surface infrastructure (roads, building ponds etc).

	Input Variable	Value	Reference
W_a	Area required for a single well pad with one well (m^2)	5877	3
L_a	Area required per lateral (m^2)	339	3
L_n	Number of laterals	10	4
L_l	Lateral length (m)	500 / 750 / 1250	3, 5
L_w	Lateral width (m)	0.14 / 0.2	5
B	Setback distance (m)	152 / 305 / 457	6 - 10
φ	Recovery factor (%)	10 - 35	4, 11
R	Estimate resource (tcm)	23.3 - 37.6 - 64.9	12

Table 1: The input variables extracted from the literature for the empirical approach. The resource estimate is given as a range (low-expected-high case scenarios). Three fixed values have been used for lateral length and setback distance.

Input Variable	Range	Reference
L_n	6 – 10	4, 13
L_l	500 – 3500 m	3, 4, 5, 14, 16, 16
φ	5 – 35 %	4, 11
R	0.04475 Mm^3/ m of lateral	4

Given the range of situations where shale gas is either being exploited or considered and the uncertainty within resource estimates, a stochastic approach was taken to determine the relationship between technically recoverable reserves and the carrying capacity of the surface using inputs from Table 2.

Table 2: The input variables extracted from the literature for the stochastic approach.

3. Results

- A single-well pad with 10 wells would generate a surface footprint (S_f) of 8928 m^2.
- A 750 m and a 1.25 km lateral would create a subsurface footprint (S_{sf}) of 1.05 km^2 and 1.25 km^2, respectively.
- The indirect surface footprint (I_f) for a well pad with a 152 m, 305 m and a 457 m setback distance (B) from the wellbore is 92416 m^2, 372100 m^2 and 835396 m^2, respectively.
- The shorter the setback distance (B) the more sites that can be located per block (Figure 3).

Figure 3

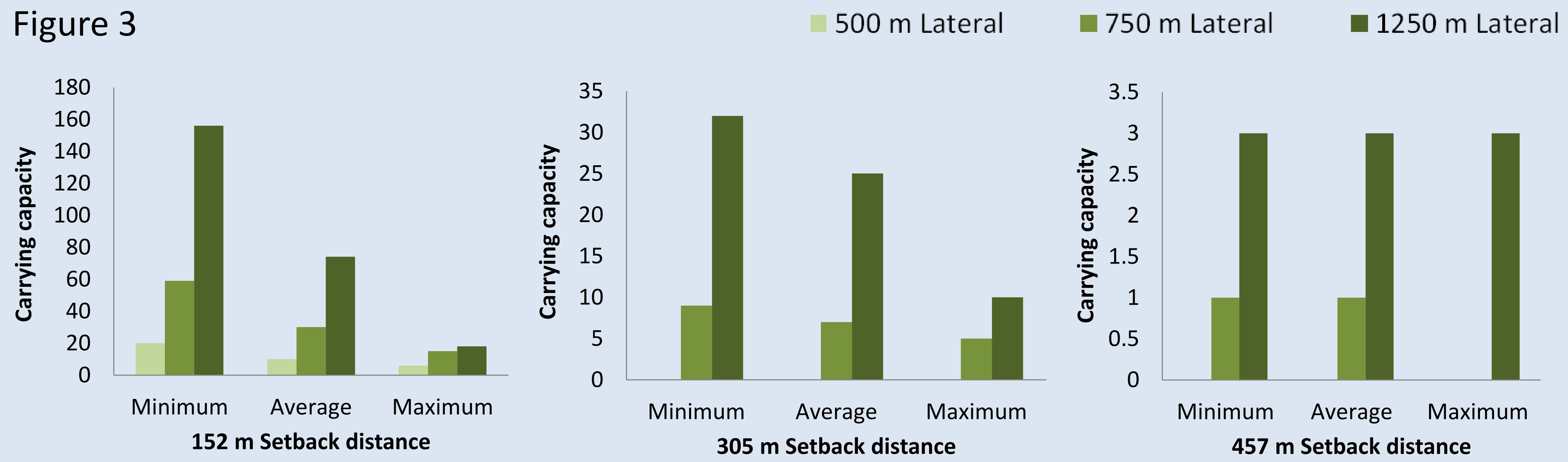


Figure 3: The minimum, average and maximum number of well pads with setbacks of 152 m, 305 m and 457 m and laterals of 500 m, 750 m and 1.25 km that can be located within a licence block.

- The average carrying capacity for a random licence block where well pads have a setback distance of 152 m and 10 laterals, each 1250 m long was 15 (Figure 4).

Figure 4: An example of the carrying capacity for a random licence block. Note images not to scale.

- Generally an increase in lateral length increases the technically recoverable gas reserve. However in licence blocks that have less existing infrastructure a greater volume of gas will be recovered with a 750 m lateral rather than a 1250 m lateral (Figure 5).

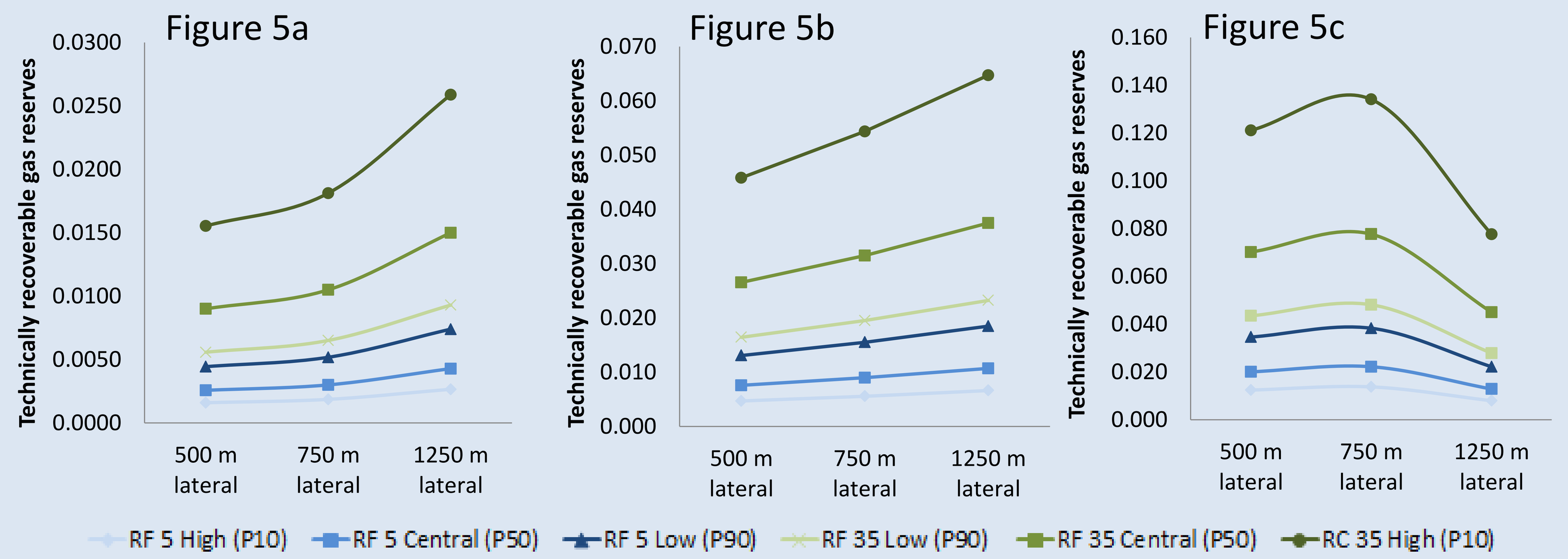


Figure 5: The central technically recoverable gas reserve (bcm) estimate for a license block, using the minimum (Figure 5a), average (Figure 5b) and maximum (Figure 5c) carrying capacity of a licence block when the well pads have a setback distance of 152 m.

- The results from the stochastic approach show that the optimal lateral length for a licence block located over the Bowland Shale is 1250 m.

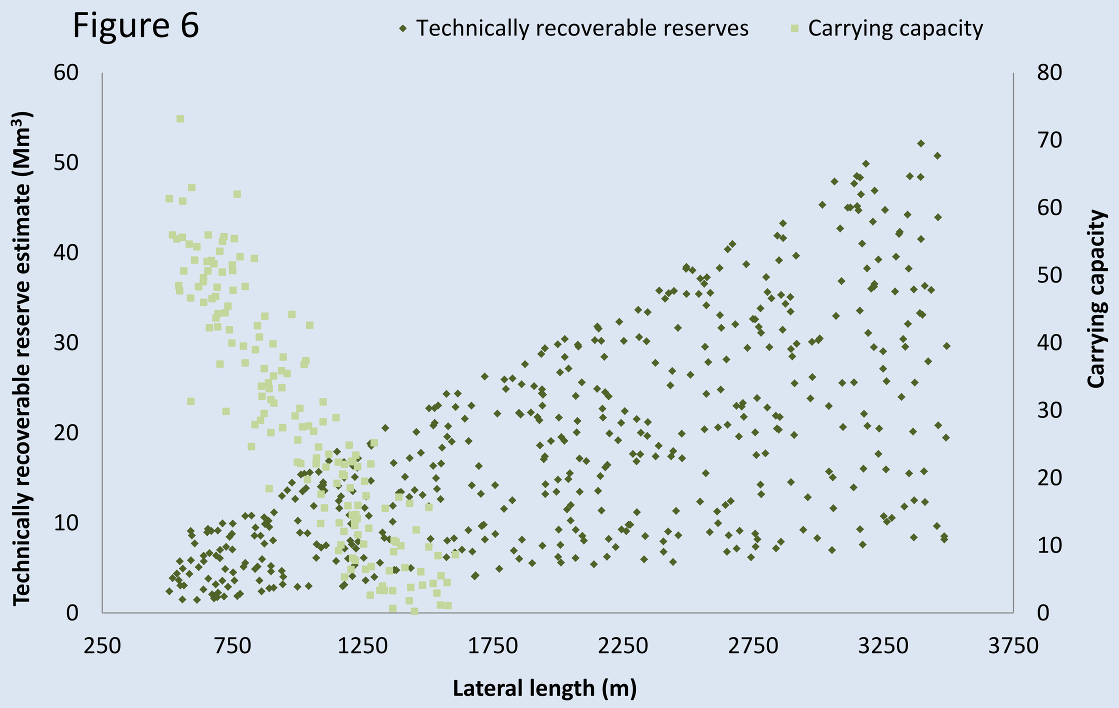


Figure 6: A graph to show lateral length against technically recoverable reserve estimates and carrying capacity.

4. Conclusion

- In general longer laterals reduce the surface footprint and generate greater volumes of technically recoverable gas reserve.
- However this is not always the case and licensed blocks need to be assessed individually.

References: 1. Baranzelli et al. (2015); 2. Stamford and Azapagic, (2014); 3. Clancy et al. (2018); 4. Taylor et al. (2013); 5. Bond et al. (2014); 6. Eshleman and Elmore, (2013); 7. Fry (2013); 8. Illinois Department of Natural Resources, (2014); 9. State of Colorado Oil and Gas Commission, (2013); 10. State of Colorado Oil and Gas Commission, unknown; 11. EIA, 2015; 12. Andrews, (2013); 13. Jiang et al. (2011); 14. EIA, (2016); 15. Cuadrilla Bowland Ltd., (2014); 16. Cuadrilla Resources, (2017).