New information on
Planning applications by Cuadrilla Bowland Limited to drill at Preston New Road (no. LCC/2014/0096)
and
Roseacre Wood (no. LCC/2014/0101)
Objection on grounds of geology and hydrogeology
by

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Summary

New information has emerged since my previous submissions to LCC and presentations to the Development Committee in January 2015.

The Environment Agency's decision document regarding Roseacre Wood is, like its earlier decision on Preston New Road, inconsistent on the question of whether or not the Woodsfold Fault is transmissive to fluids. This fault separates the zone planned for shale gas development below the Fylde from the important sandstone Principal Aquifer to the east between Preston and Garstang.

The EA concludes that the deep groundwater resource in the Sherwood Sandstone Group (SSG) below the whole of the Fylde is unusable for drinking because it is highly saline. But this is not supported by data from the Kirkham deep well and other water wells, nor from historical evidence. The hypersaline samples taken in the Kirkham well probably resulted from halite (salt) beds in the Mercia Mudstone Group, and have no direct bearing on water quality of the deeper SSG.The geology of the area around Kirkham is far more complex than appears on publications and maps of the British Geological Survey, which have been altered several times to try to account for new data.

A new hydrogeological modelling study of Fylde geology shows that under certain circumstances of hydraulic fracturing of the Bowland Shale, the SSG aquifer could be contaminated in about 100 years by fracking fluid. The study has many flaws, but more work is required in this area of research before drilling starts.

A paper recently published by Cuadrilla Resources Ltd in the scientific literature has located the earthquakes on a fault triggered by the Preese Hall-1 well in 2011. The fault lies some hundreds of metres east of the wellbore. My re-analysis of the fault identified by this paper shows that it runs at a lower angle than interpreted by Cudrilla, and passes through the wellbore itself. This explains the severe well casing deformation. The main lesson from this study is that important faults in the thick Bowland Shale are very hard to identify.

Legislation on the questions of the safe minimum horizontal distance that fracking should take place from pre-existing faults has not yet been defined. There is also legal uncertainty about the fate of produced water from any eventual shale gas production; can it be re-injected back down adjacent boreholes, or not?

I therefore recommend to LCC's Development Control Committee that it puts in place its own fracking moratorium until such time as the outstanding problems are resolved. This means that both the proposed developments should be refused.

Introduction

I am reluctant to burden the Lancashire County Council Development Control Committee with more information regarding the two planning applications cited above, following my previous written submissions and presentations to the committee on 23 and 26 January 2015. However, more information has since come forward which is relevant to the applications. I am providing this report as a short summary of the new findings.

As the Committee will be aware, my objections to both of the developments are principally on grounds of potential contamination to groundwater resources. The decisions by the Environment Agency to approve the applications are crucially important, but I believe are wrong and misguided, and should therefore be disregarded by the Development Control Committee.

Environment Agency decisions

The Environment Agency's decision document concerning groundwater protection at Roseacre Wood (published 6 February 2015) is almost identical to that for Preston New Road. The most important question is whether or not the Woodsfold Fault is transmissive or a barrier to fluids. This fault separates the zone planned for shale gas development below the Fylde from the important sandstone aquifer to the east between Preston and Garstang. I pointed out in my presentations to the Development Control Committee that the EA is inconsistent on the hydrogeological nature of the fault, and does not appear to understand the implications of fracking for future groundwater flow and contamination. I develop some of my arguments further below using the new information.

The EA also concludes that the deep groundwater resource in the Sherwood Sandstone Group below the whole of the Fylde is unusable for drinking because it is highly saline. But this is based on extrapolation from only one deep well, at Kirkham, and is not supported by data from other water wells, nor from historical evidence. The geology of the area around Kirkham is far more complex and less well-understood than appears on publications and maps of the British Geological Survey (BGS). The well evidence and the geology are discussed below.

The evidence for saline groundwater west of the Woodsfold Fault

Under FOI/EIR regulations I asked the EA for information on the chemistry of the water in a number of water wells in the Fylde area, and obtained this information on 30 March 2015. My aim was to examine the evidence for the Sherwood Sandstone Group (SSG) aquifer west of the Woodsfold Fault being saline and therefore undrinkable. The EA view is that this water is stagnant and never recharged, and that over a long period the water has dissolved minerals from the rocks. But the top of this aquifer is only at around 300 m depth below the relatively impermeable Mercia Mudstone Group (MMG), and groundwater is normally fairly fresh at such a depth. Groundwater normally only becomes saline rather deeper, say at depths of greater than 500 m.

Figure 1 shows the location of some of the water wells labelled in blue, and the exploration boreholes, actual and proposed, labelled in red. The area where the MMG is at the surface (outcrop below recent glacial deposits) is uncoloured. The SSG outcrop is shown in a buff colour. Major faults as mapped by the BGS at the surface are shown in red with a comb on the downthrown side. The Principal Aquifer lies generally east of the Woodsfold Fault, and the abstraction wells here are generally drilled to 100 m or shallower depth.

Potable water is defined as having a chloride content of less than 250 mg/l. Seawater has a typical salinity of 35,000 mg/l (i.e. 35 parts per thousand or 3.5%) Some of the water in the Kirkham borehole is hypersaline, with salinity of up to 91,000 mg/l. There were three such hypersaline samples taken at Kirkham. Two of these were measured at around 250 m depth, within the MMG; the third was measured at an unrecorded depth. Sixteen other samples, five of which come from shallow depths (around 17 m) have low salinity (224 mg/l or less). The top of the SSG here is at 366 m depth. Therefore it would appear that the groundwater within the SSG has not been sampled. The hypersalinity of the three samples can be explained by dissolution of thin halite layers within the MMG.

Two kilometres west of the Kirkham well there was a borehole drilled to 445 m depth for the Phoenix cotton weaving mill. This depth is well into the SSG. No details of the water quality and use survive; this is confirmed by an enquiry from the BGS to the mill owners in 1941.There is no information regarding the well at Chapel Farm, Wesham, and information for the well at Blackburns Farm is confidential. The log sheet for New Hey Farm, 1 km SE of the Kirkham borehole, is blank, although its depth is given as 131 m.

The borehole at Freshfield Farm, 2 km south of the Kirkham borehole, was only drilled to 32 m, but apparently encountered SSG at 30.2 m. The water is fresh.

The well at Rowe's Model Dairies at Inskip, 2.7 km NE of the proposed Roseacre Wood well, was originally drilled in 1940 to 91 m, entirely within the MMG, but the yield was low. It was re-drilled deeper, encountering the SSG at 149 m and penetrated it for 12 m. Water yield was very high, at 3000 gall/h. However, it was abandoned in 1956 due to 'insufficient yield'. There is no information on water quality, but given the fact that the business was a dairy and later a cheese factory, it is likely to have been used for consumption, directly or indirectly. Local enquiries may provide some historical evidence on the well water quality.

Two kilometres to the SE of the Inskip well there is the Woodsfold Bridge well. It has a high yield of very fresh water from the SSG, the top of which is at 46 m depth below thin MMG.

None of the above evidence can justify the EA's over-simplified claim that the SSG aquifer below the Fylde can be discounted as a resource. It has clearly been used in the past. More local research is required to find out about the old wells, in addition to a more detailed study of the complex geology of this area.

Geology of the Woodsfold Fault area east of the proposed well sites

The BGS solid geology maps show the Woodsfold Fault cropping out as a nearly straight line, as shown in Figure 1. But the actual location is poorly defined, because surface geological exposure is extremely limited, and the seismic information is very poor. Evidence for uncertainty includes the fact that the recent deep mapping by the BGS using seismic data conflicts to some extent with the surface maps, by up to 1 km. The interpreted sliver of MMG on the east side of the Fault, where the Woodsfold Bridge well is situated, is somewhat unsatisfactory; a better explanation of the surface geology is to place the Woodsfold Fault at outcrop just east of the water well. This solution would accord better with the recent BGS deep mapping using 2D seismic data.

Further south, the outcrop of SSG west of the Woodsfold Fault is unsatisfactory. It straddles two geology sheets; a small triangular area on the Garstang sheet, marked with a G on Figure 1, and the larger area P to the south. The Garstang sheet dates from 1990. The sliver of SSG in the Preston sheet may have been added as a new interpretation following the drilling of the Freshfield Farm well in 1988, discussed above. This interpretation is present in the BGS digital database, but has been removed from the new edition of the Preston sheet, dated 2012. On this sheet and its accompanying cross-section running through Kirkham the SSG is at nearly 1000 m depth, and there is no outcrop of the SSG west of the Woodsfold Fault.

I have inspected the available 2D seismic data in the area of Figure 1, using the UK Onshore Geophysical Library website, where small-scale images of the seismic lines may be viewed. It is apparent that the geology west of the fault is quite complex, with many faults and folds, and local areas of steep dip. The bedding dips measured in the Kirkham borehole are frequently very steep (40°-70°), particularly in the MMG; this is further indirect evidence of complex structure.

I conclude that more geological studies are needed to provide a sound foundation for understanding the hydrogeology of this area. These could best be carried out by the BGS, in conjunction with additional fieldwork as and when required.

Hydrogeological modelling of the Fylde

Only four modelling studies have been published to date, worldwide, on the influence of faults on fluid flow resulting from fracking operations. The aim of these studies is to create a computer model of the geology of interest, including natural geological faults, then add in the hydraulic fracturing process and predict where and how rapidly the fluids (gas and water) migrate. Given that such studies can be carried out on a PC, and can be achieved with a few months' work in the office, it is remarkable that so few have been undertaken.

The most recent of these studies concerns the Bowland Shale in Lancashire (Cai and Ofterdinger 2014). The authors built a layer-cake computer geological model of the geology at the Preese Hall-1 well, then added in hydraulic fractures (fracks) in the Bowland Shale near the bottom of the model. No faults were built in to the model to start with. The effect of faults was crudely simulated in some models by extending six of the fracks upwards into the SSG.

All the four studies to date have their own flaws and limitations. How one defines the 'boundary conditions' is especially important, and can greatly affect the results. In short, the results depend largely upon how one sets up the model. For example, if one sets the fluid flow into the model to enter at the bottom, then naturally the fluid flow is going to be upwards.The Bowland Shale study did that, which is acceptable, but it also defined the MMG, the top layer, as impermeable. This is somewhat unjustified, as the MMG is poorly permeable, but not a complete seal to fluids. So where does the fluid flow? In the Bowland study the flow is upwards and out to the side (actually out along the right-hand-side only, because a horizontal gradient, or 'head' was also defined to mimic the effect of regional groundwater flow from the Bowland Fells westwards towards the Irish Sea).

The Bowland Shale study found that the SSG aquifer could become contaminated on the order of 100 years under certain conditions. Most of the flow was diverted sideways within the Collyhurst Sandstone, which is a high permeability layer between the SSG above and the Bowland Shale at depth.

In conclusion, the Cai and Ofterdinger study is flawed, principally because the representation of major faults by vertical fractures up to 1 mm in width is unrealistic; but it is a positive start. More realistic hydrogeological models should be constructed, with a variety of boundary conditions applied, for each of the development sites, before any actual drilling is carried out, to test the likely flow patterns of potential contaminants.

Mapping of the earthquake faults at Preese Hall-1

Cuadrilla has recently published a paper (Clarke *et al.* 2014) on the location of the earthquakes triggered by the drilling of Preese Hall-1 in 2011. I have no issue with the earthquake location, but the angle of the fault that slipped during the earthquakes is suspect.

The earthquake location on a fault plane, the hypocentre, is shown by the lilac ball (Fig. 2). The extrapolation upwards of the fault plane misses the wellbore, according to the original interpretation of Clarke *et al*. According to them the fault is shown on the 3D seismic data volume running upwards to the west from the hypocentre, but dying out about 100 m east of the wellbore (the dashed red line in Fig. 2). Such an interpretation mismatches the seismic data, because the dashed line representing the fault in Figure 2 cuts across the westerly-dipping seismic layering. I have re-interpreted the fault position (Smythe, for submission) to honour the seismic data, as shown by the solid red line in Figure 2. This version is consistent with the earthquake focal plane solution, and intersects the wellbore. It also shows that the fault runs through the well in the zone where the well casing was deformed. The earthquakes and the deformation happened shortly after frack stage 2, shown in yellow on the wellbore (Fig. 2).

The lesson to be learned from Preese Hall and Cuadrilla's subsequent explanation of the faulting is that faults in thick shale basins are extremely hard to identify. The best hope for resolving this problem is to conduct a particular type of detailed 3D seismic survey in advance of any drilling. The existing 3D survey obtained in 2012 was correctly described by Cuadrilla as 'preliminary', and appears to be inadequate for identifying faults accurately.

Unresolved regulatory matters

The question of a safe minimum horizontal distance between a volume of fracked shale and pre-existing geological faults has not yet been resolved. The fact that such a distance, called a *respect* or *stand-off* distance, needs to be defined is an implicit admission that faults may be pathways for contamination. It also begs the question of how these faults will be recognised in advance of drilling, as discussed above.

Professor Peter Styles has recently presented a paper in co-authorship with Cuadrilla and its subcontractors (Styles *et al.* 2015), which took place at a symposium in Davos,10-13 March 2015. It is noteworthy from his slideshow that Styles is in the process of making "*Preliminary Recommendations to UK PM's Office*" (slide 20), while at the same time he is working closely with the nascent UK unconventional shale industry and its subcontractors. The four authors of the Davos presentation are the same four who wrote the Preese Hall-1 earthquake paper, but with a different lead author. I therefore question Styles's independence from the industry, and why he alone seems to have the ear of government on this issue, without wider consultation and open scientific discussion. Nevertheless, he depicts a possible stand-off distance varying from a minimum of 850 m up to 5000 m.

Even if the minimum value of 850 m were to be adopted, it would rule out both developments from taking place at all. This is further evidence that much new legislation and scientific research must be carried out before any test fracking takes place.

The EA appears to be either inconsistent or ignorant about whether or not re-injection of produced water into nearby boreholes, as a means of disposal, is legal or not. The EA response to a recent enquiry made by a private individual living in Kent is attached as Appendix A. It explicitly states (the two bullet points) that produced water may be re-injected, and that flowback water may either be re-used on-site as fresh injection fluid or else treated as waste. In contrast, in the email exchange between Mr Mike Hill, C.Eng. MIET and the EA concerning the same problem in the Lancashire context (reproduced as Appendix B), the EA seems to imply the opposite – that re-injection is prohibited.

Clearly there is regulatory confusion, which must be resolved before permits are issued, and drilling and fracking takes place.

Conclusions

1. The geological structure east of Preston New Road and south of Roseacre Wood is complex and as yet rather poorly resolved.
2. The locations of the major faults such as the Woodsfold Fault are poorly determined.
3. The evidence for general high salinity of the groundwater in the SSG below the Fylde is weak; it could in fact be fresh and serve in the future, as it has in the past, as a groundwater resource.
4. The Environment Agency does not understand sufficiently well the geology and hydrogeology of the Fylde. Its decisions to approve both the applications should therefore be disregarded.
5. Recent hydrogeological modelling of fractures representing vertical faults in a layer-cake model of Fylde geology is flawed in several respects, but does, however, demonstrate that contaminated fluids and gases can reach the SSG from below as a result of fracking, within about 100 years.
6. As shown by the interpretation around Preese Hall-1, the applicant has great difficulty in correcting identifying and mapping faults within the target Bowland Shale, even with the currently existing preliminary 3D seismic data. A more detailed 3D seismic survey, together with ancillary geophysical methods, needs to be obtained and interpreted before any fracking is attempted.
7. No 'respect' or stand-off distance has yet been determined for avoiding fracking near to faults. Even the minimum value recommended by Professor Styles would in effect preclude all fracking at these two sites.
8. The question of whether or not re-injection of produced water from fracking into nearby boreholes is to be permitted has not been resolved.

It is widely recognised that the Fylde area is the flagship, or testbed area, for shale gas fracking in the UK. It is evident from the points presented above that a moratorium, at the minimum, needs to be put in place to prohibit any drilling until such time as the various geological and hydrogeological problems have been resolved. It is a pity that the parliamentary motion to put such a moratorium in place did not succeed last January.

I therefore recommend to LCC's Development Control Committee that it puts in place its own moratorium, which means that the two proposed developments should be refused.

References

Cai, Z. and Ofterdinger, U. 2014. Numerical assessment of potential impacts of hydraulically fractured Bowland Shale on overlying aquifers. *Water Resources Research*, 50, 6236–6259, doi:10.1002/2013WR014943.

Clarke, H., Eisner, L., Styles, P., and Turner, P. 2014. Felt seismicity associated with shale gas hydraulic fracturing: the first documented example in Europe, *Geophys. Res. Lett.* 41(23), 8308-8314, doi:10.1002/2014GL062047, 2014.

Smythe, D. K.: Hydraulic fracturing in a thick shale basin: seismic reflection methods do not reliably predict faults in the Bowland Basin, Lancashire, UK. For submission to *Solid Earth*, 2015.

Styles, P., Eisner, L., Clarke, H. and Turner, P. 2015. Seismicity induced by Shale Gas Hydraulic Stimulation: Preese Hall, Blackpool, United Kingdom. Paper presented to the Schatzalp Induced Seismicity workshop, 10-13 March 2015, Davos, Switzerland.

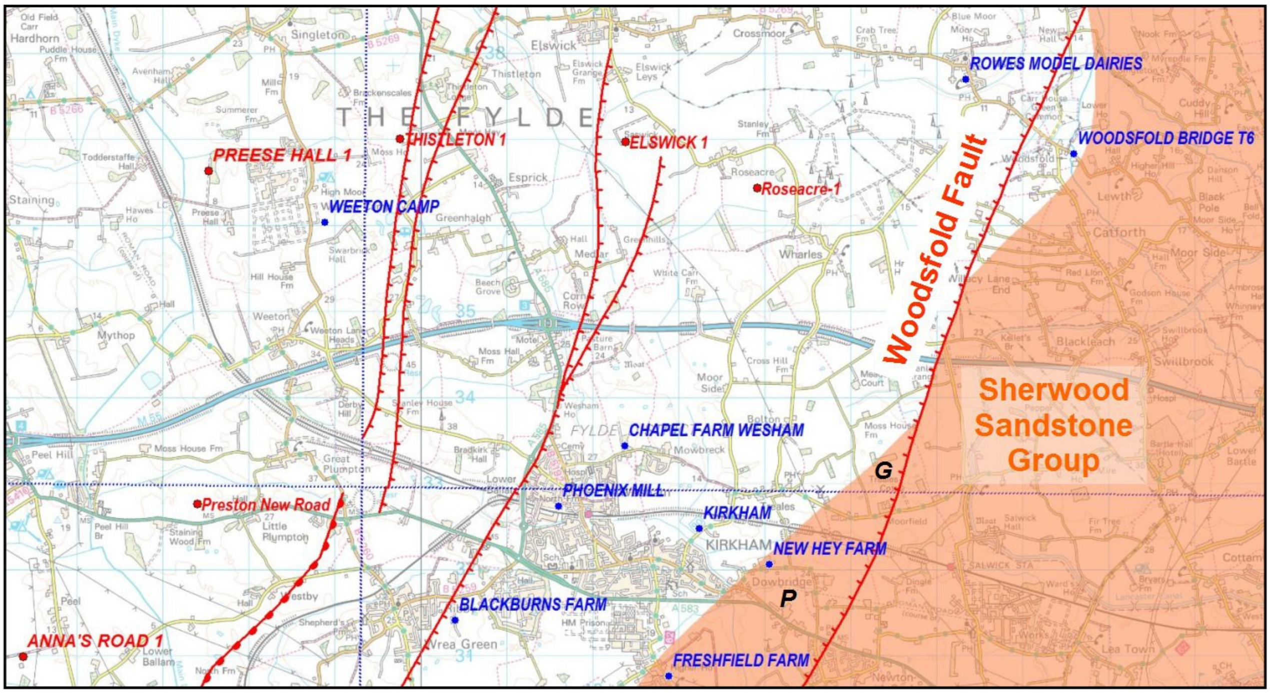

Figure 1. Selected water and other investigation boreholes (blue labels) in the Fylde area. Existing and proposed hydrocarbon exploration wells are shown in red. Surface outcrops of faults as mapped by the BGS are shown by red lines with a comb on the downthrown side. Thin blue dotted lines mark the boundaries of four BGS map sheets.

The outcrop of the Sherwood Sandstone Group is shown in buff. The blank area is the outcrop of the Mercia Mudstone Group. Letters G and P indicate controversial areas of SSG outcrop west of the Woodsfold Fault as marked on the BGS Garstang and Preston sheets, respectively.

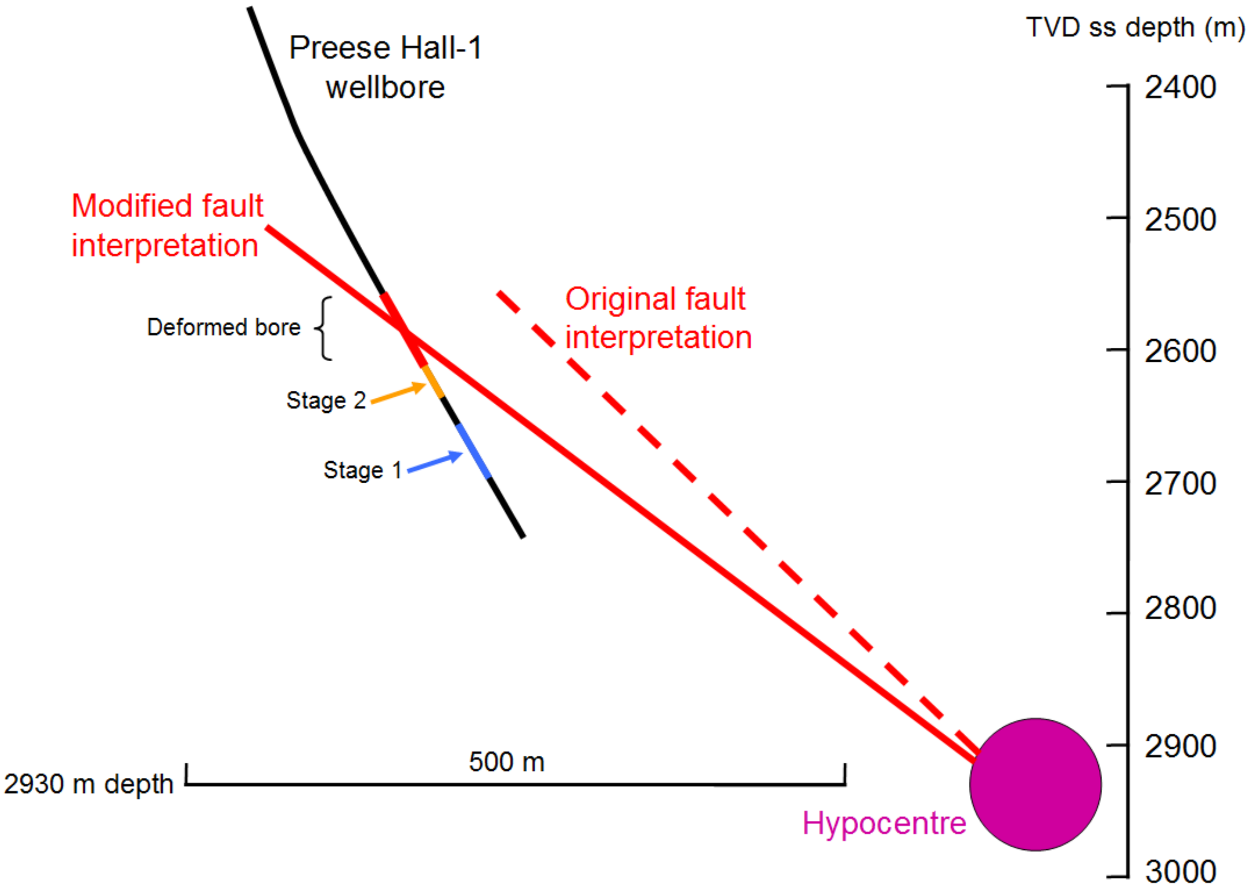

Figure 2. Vertical east-west plane through the bottom part of the Preese Hall-1 well (from Smythe, for submission). The earthquake location (hypocentre) on a fault plane is shown by the lilac ball (Clarke *et al.* 2014). The extrapolation upwards of the fault plane misses the wellbore, according to the original interpretation of Clarke *et al.* My re-interpretation both matches the 3D seismic data better, and also shows that the fault runs through the well in the zone where the well casing was deformed. The earthquakes and the deformation happened shortly after frack stage 2, shown in yellow on the wellbore. TVD ss – true vertical depth sub-sea level.

Appendix A

Response by south-east branch of the Environment Agency to an enquiry about re-injection of produced and flowback water

From: "Press Office, South East" <SOUTHEASTPRESSOFFICE1@environment-agency.gov.uk>
To: XXXXX
Sent: Tuesday, 10 February 2015, 10:54
Subject: Re: Urgent press info request - UK regulations / permitting requirements

Hello XXXX – in response to your email to Simon Deacon from Saturday please see our statement below. I hope this gives you the information you're looking for. If you can send to/copy in the Press email account into any enquiries in the future the 'on duty' press officer will be able to help you.

• Operators may re-inject produced water back into the geological formation either to stimulate production or for disposal. This reinjection is allowed under Environmental Permitting Regulations *(paragraph 8(a) of schedule 22 EPR 2010).* The intention is to allow for the return of water naturally present in geological formations.

• Flowback fluid from hydraulic fracturing can be treated and reused on site as fresh injection fluid and we consider this to be a suitable environmental option. Flowback fluid that is not suitable for reuse is considered to be waste. Operators must send this to an appropriate permitted waste facility for treatment or disposal. Operators will not be allowed to reinject flowback fluid for disposal into any formation.
Kind regards
Lee

Lee Spicer-Howard

☎ External: 0118 953 5555
southeastpress1@environment-agency.gov.uk,

South East Press Office
Environment Agency

Appendix B

Edited email exchanges between Mike Hill and Environment Agency, February-March 2015

Forwarded to David Smythe by Mike Hill, 29 March 2015

From: Mike Hill [mailto xxxxx]
Sent: 25 February 2015 13:25
To: Molyneux, Steve
Cc: xxxxx
Subject: Waste in the Shales and the MWD

Hi Steve,

[xxxxxxx]

How are the EA permitting the waste that remains down the borehole? So for us that's approx. 50% so around 13million litres per borehole. That must be proven to remain in the target formation – the shales. How are you satisfied that this is the case? You cannot issue a permit until you are and you have issued permits now. Can you explain how as there are a number of expert geophysicists explaining through various papers that no operator could prove this – yet a Lord Smith (when he was chair of the EA) has stated the Mining and Waste Directive (via the EPR2010) does indeed apply to that waste as well.

Also Steve the Infrastructure Bill has stated that "any substance" can be left/pumped down a borehole post frack. On recent panels I have sat on the industry has expressed its clear intention to make use of this and so not transport flowback to treatment facilities but "treat" on the pad and then inject the waste into boreholes. This is commonly referred to a re-injection and in theory banned in the UK but not anymore it would seem. Both John Dewar (Third Energy) and F.Egan (Cuadrilla) have recently stated this in public meetings. Can you explain the EA's view on this?

Regards,

Mike

From: Molyneux, Steve [mailto:xxxxx]
Sent: 11 March 2015 18:13
To: 'mike.hill@xxxx
Cc: xxxx
Subject: RE: Waste in the Shales and the MWD

Thanks Mike, apologies for the delay here. I have been on leave and picking up your email on my return.

I've attached a link to the Environment Agencies Decision document for the issue of the Environmental permits for Roseacre.

PR4 3UE: Environmental permits issued - Publications - GOV.UK

Section 5.1.10 explains about the retained fracture fluid in the formation with Section 7.5 setting out groundwater protection

Section 5.1.8 Explains about the reuse of flowback and confirms that there is a prohibition on injection of fluids for disposal purposes.

Hope this helps

Best Regards

Steve

From: Mike Hill [mailto:xxxxx]
Sent: 15 March 2015 16:52
To: Molyneux, Steve
Subject: RE: Waste in the Shales and the MWD

Hi Steve,

I am afraid that hasn't answered the questions as I would have hoped. Would you mind looking at them again for me?

That (fracking waste) must be proven to remain in the target formation – the shales. How are you satisfied that this is the case? You cannot issue a permit until you are and you have issued permits now. Can you explain how as there are a number of expert geophysicists explaining through various papers that no operator could prove this – yet a Lord Smith (when he was chair of the EA) has stated the Mining and Waste Directive (via the EPR2010) does indeed apply to that waste as well.

Section 5.1.10 – Here Steve you basically state that as it is hard to extract the waste then leaving it in is a BAT (Best Available Technique) ! Astonishing really but that's what you state. What you actually mean is that there is no BAT and so instead of stating it cannot happen under the EPR2010 , you state – let's do nothing. As an engineer I am afraid doing nothing is not really a technique. It's just doing nothing.

What you have not addressed is leakage (migration) of this fluid out of the shales and up to the aquifer. There are a number of papers addressing this issue and the detail that the buoyancy of the fracking fluid compared to the surrounding formation solutions in the Bowland shale means that it will rise given the opportunity to do so. Faults are just such an opportunity. As for non haz, your own sample showed that it contained lead, cadmium, arsenic, radioactive sludge at many times the safe level for drinking water. As this fluid cam migrate to the aquifer and the food chain then I am a little perplexed how you can decide it is non hazardous. Can you explain?

Steve, the Infrastructure Act allows for re-injection through the "any substance" clause and the industry has said directly to me and in public meetings it will use this to treat on the pad and then pump down flowback rather than tanker off to treat it. What would you call this practice ? I call it re-injection. They appear to be happy to do this despite your statement it is banned? Both John Dewar (Third Energy) and F.Egan (Cuadrilla) have recently stated this in public meetings. So what will the EA do to enforce its position that this is banned?

Regards,

Mike

From: Molyneux, Steve [mailto:xxxxx]
Sent: 23 March 2015 16:59
To: 'mike.hill@xxxxx'
Subject: RE: Waste in the Shales and the MWD

Thanks Mike

During the public consultation on the Environment Agency permits concerns were raised on the accumulation of waste fracturing fluid underground. Most respondents cited a paper published by Professor Davies which expressed concerns that hydraulic fracturing wastes, including NORM (Naturally Occurring Radioactive Materials), may migrate to other formations and eventually cause contamination.

Professor Davies has published a follow up to his paper on fracture propagation which states that the paper was based on purely statistical probabilities and that his findings are therefore blind to factors such as local geology and the operational factors such as the volumes of fracture fluid to be used and that these do need to be considered on a site specific basis to produce meaningful data.

We have taken a conservative approach and this is why appropriate mitigation measures have been proposed and included throughout the Permit. These will limit the potential of fracture propagation beyond the target formation and this will in turn reduce the chances of fracture fluid being lost to other formations. These mitigation measures include the stepped approach to the hydraulic fracturing process, using small volumes of fluid initially and monitoring the propagation of the fractures using the seismic arrays, then increasing the volumes used up to a maximum volume which has been proposed at a much reduced volume than previously used at Preese Hall, and is limited in the Permit.

The Hydraulic Fracture Plan to be approved by DECC will also need approval by the Environment Agency prior to hydraulic fracturing commencing and this will be a condition of the Permit. The plan will be designed to ensure that the propagation of fractures is carefully monitored.

See section 7.5 of the Decision Document and the potential impact of activity on surface water and groundwater section for more details.

The fluid used for hydraulic fracturing will contain only additives that have been assessed as non-hazardous to groundwater as defined in the Groundwater Directive, this limitation applies at all times and is enforced through a condition in the permit, including where the fracturing fluids' composition includes re-used flowback fluid. Hazardous wastes are defined under the Hazardous waste Regulations (Classify different types of waste - GOV.UK). A waste wouldn't be classed as hazardous because it doesn't meet drinking water requirements. Nevertheless, this doesn't mean that it couldn't be potentially polluting and hence the need for controls under the Environmental permits as above. Retained Hydraulic Fracturing Fluid is classified as Wastes from mineral non metalliferous excavation (01 01 02) – Non Hazardous

I'm not sure I can add any more to my previous email on the issue of re-injection for waste disposal there is a prohibition on injecting fluids for disposal purposes. Flowback fluid that it is not suitable for reuse will be sent to an appropriately permitted waste facility for treatment or disposal. Flowback fluid will be re-used for hydraulic fracturing wherever the level of total dissolved solids are compatible, which may require dilution with mains water, with the friction reducer. This will involve utilising a closed loop system between hydraulic fracturing stages to ensure that all flowback fluid (post separation from any gas and sand) is captured and is available for re-injection into the target formation as part of the hydraulic fracturing process. Flowback fluid that has been separated from the sand and natural gas will be stored at the surface in enclosed steel containers on top of the well pad membrane. The Permit includes a requirement for the Operator to monitor the composition of the hydraulic fracturing fluid (which may include flowback fluid), in particular to demonstrate that no hazardous additives have been used and that the fluid injected remains non-hazardous. The monitoring results will be made available to the Environment Agency and will be available on the Public Register. The Environment Agency will of course be inspecting against these requirements and undertake out own check monitoring were warranted.

I hope this is helpful.

Best Regards

Steve