

To:	Environment Agency	From:	Envireau Water
Ref:	P:\Third Energy KMA (1996)\40 - Reporting\PreOp Conditions\PO5\TN r5.docx	Pages:	4
Re:	KM8 Mining Waste and Groundwater Activity Permit Pre-operational Condition 5	Date:	21/07/2017

1 Introduction

Third Energy UK Gas Limited (Third Energy) is proposing to hydraulically fracture an existing hydrocarbon well (KM8) at Kirby Misperton A Wellsite, North Yorkshire ("the KMA wellsite").

A mining waste and groundwater activity permit (Ref. EPR/DB3002HE) was issued by the Environment Agency for the hydraulic fracturing operation in April 2016. The permit includes five pre-operational measures (PO1 – PO5). PO5 states:

Prior to the operation of the regulated facility the Operator shall submit a written report to the Environment Agency including the details from the deep monitoring borehole (BHE) at KM8 drilled into the Corallian Limestone Formation. The report will include but is not limited to, the location of the faults and a description of how the currently used groundwater in the Corallian Limestone will be protected.

This report has been prepared by Envireau Water to fulfil the requirements of PO5 and is intended to be submitted to the Environment Agency prior to the hydraulic fracturing operation.

Please note that this report does not provide a description of the regional geology and hydrogeology, which is covered in detail in the Hydrogeological Risk Assessment that was prepared by Envireau Water in May 2015 [Ref. 1].

2 Groundwater Monitoring Boreholes at the KMA Wellsite

To comply with the Environment Agency requirement to establish a water quality baseline ahead of the proposed hydraulic fracturing, five (5) monitoring boreholes were constructed at the KMA wellsite in December 2015, as follows:

- Three (3) boreholes ("the shallow boreholes") targeting the superficial deposits/weathered zone of the Kimmeridge Clay Formation.
- One (1) borehole ("the intermediate borehole") targeting the un-weathered Kimmeridge Clay Formation/Amphill Clay Formation (Ancholme Group).
- One (1) borehole ("the deep borehole") targeting the top ~30m of the Corallian Group.

Construction details for all the monitoring boreholes have been documented in an 'as-built' construction report [Ref. 2] to fulfil the requirements of PO4 of the permit and should be read in conjunction with this technical note.

3 Corallian Borehole

Construction details for the deep Corallian borehole (BHE) are documented in Ref. 2. The Corallian borehole is located at NGR SE 77110 78969 as shown on Figure 1 in Ref. 2.

Table 2 of Ref. 2 summarises the borehole construction details for the Corallian borehole (BHE) and have been reproduced in Table 1 of this technical note for completeness.

Table 1 Corallian Borehole (BHE) Construction Details

Borehole ID	Completion Depth (mbgl/ mAOD)	Drill Diameter	Casing Details	Filter Pack Details	Water Strikes (mbgl/ mAOD)	Rest Water Level	
						(mbtow)	(mAOD)
BHE	222.0/ -193.1	305mm (12") from 0 to 10.5 mbgl (28.9 to 18.4 mAOD) 216mm (8" 1/2) from 10.5 to 195.0 mbgl (18.4 to -166.1 mAOD) 114mm (4" 1/2) from 195.0 to 222.0 mbgl (-166.1 to -193.1 mAOD)	140mm ND steel casing from 0 to 192.6mbgl (28.9 to -163.7 mAOD)	Open hole from 192.6 to 222.0mbgl (-163.7 to -193.1 mAOD)	7.6 / 21.3	3.01 on 20/04/2016	26.72

Figure 4 of Ref. 2 illustrates the 'as-built' construction details for the Corallian borehole. The geology encountered during construction of the Corallian Borehole comprised:

- 0 – 1.2mbgl Made Ground/ Superficial Deposits;
- 1.2 – 4.5mbgl Weathered Kimmeridge Clay Formation;
- 4.5 – 190mbgl Kimmeridge Clay Formation/Amphill Clay Formation (Ancholme Group).
A water strike was observed in the Kimmeridge Clay at 7.6mbgl (21.3mAOD);
- 190 – 222mbgl Corallian Group. No significant water strikes were observed.

Note that the boundary between the Corallian Group and the Ancholme group is not abrupt and has a transition zone consisting of fine-grained sandstone and grey silty mudstone. Based on logging by Envireau Water of the sample returns obtained from drilling, there were no abrupt changes in the geological sequence and no evidence of faulting.

No significant water strikes were observed in the Corallian, which likely reflects the control of the drilling fluids during construction. On completion of the boreholes and flushing of the borehole, water levels rose to approximately 3m from surface.

Groundwater samples have been obtained from the Corallian borehole and analysed in the field and laboratory. The results show that the water is mineralised, with a pH in the region of 10.5 and an electrical conductivity in the region of 3,000µS/cm; and is unfit for human consumption without excessive treatment.

The groundwater chemistry of the Corallian at the KMA wellsite is discussed in technical documents to fulfil the requirements of PO3 of the permit.

4 Faults in the Vale of Pickering

The geology at the KMA wellsite is documented in Sections 4.1 and 4.2 of Ref. 1 and illustrated on Figure 4a and Figure 4b of the same report.

The KMA wellsite is located within the Vale of Pickering, where the strata is intersected by a series of east-west and northwest-southeast trending faults. Published BGS mapping data indicates that a mapped fault is present across the northern part of the KMA wellsite, trending in an east-west direction and downthrowing the strata to the north. The next closest fault is located approximately 750m to the south trending in an east-west direction and downthrowing the strata to the north. The location of faults relative to the proposed hydraulic fracturing operation at KM8 have been carefully considered and are not significant [Ref. 3].

The BGS is in the process of updating their geological mapping of the Vale of Pickering and discussions between Envireau Water and BGS have taken place to confirm that there are no new mapped faults in close proximity to the KMA Wellsite.

The Vale of Pickering is bounded by two major fault structures: the Vale of Pickering Fault located approximately 5km to the northeast and the Coxwold-Gilling-Linton Fault located approximately 5km south of the KMA wellsite, where the Corallian Group outcrops at surface. The geological faulting means that the Corallian Group beneath the KMA wellsite is structurally disconnected from the Corallian strata where it outcrops to the north and south of the Vale of Pickering and there is limited potential for active groundwater recharge.

As already described, no faults were encountered in the drilling and construction of the Corallian borehole. This is consistent with the orientation of the mapped faults indicated by the geological mapping data.

5 Groundwater Protection

Where it is at or close to outcrop, groundwater in the Corallian is an important source for drinking water and other uses. An Environment Agency Source Protection Zone has been defined where the Corallian outcrops north of the Vale of Pickering Fault, which relates to the Yorkshire Water public supply boreholes at Pickering.

The Corallian at the KMA Wellsite is isolated from the Corallian at outcrop by geological faulting through the Vale of Pickering. Consequently, the water in the Corallian at the KMA Wellsite is mineralised on account of limited groundwater recharge; and is unfit for human consumption without excessive treatment.

Third Energy proposes to hydraulically fracture the KM8 well at five intervals within the Carboniferous Bowland Shale; at depths between 2,123m and 3,044m below ground level. As shown in Ref. 3, the height of the uppermost fracture zone will potentially reach a depth of 2,049m below ground level and will be contained within the Bowland Shale.

The information collected from the construction of the Corallian borehole (BHE) validates the conceptual understanding presented in Ref. 1 and no amendments are required to the risk assessment. It can be concluded that the proposed hydraulic stimulation will not create a pathway between the KM8 well and the Corallian. It will not be possible for hydraulic fracture fluids to migrate to any water bearing formations above the Bowland Shale and consequently none are at risk.

Envireau Water
21/07/2017

REFERENCES

- Ref. 1 Hydrogeological Risk Assessment. KM8 Well, Kirby Misperton A Wellsite, North Yorkshire. Envireau Water, May 2015. Ref: P:\Third Energy KM8 (1636)\HRA\Report\KM8 HRA Report r5.docx
- Ref. 2 KM8 Monitoring Boreholes As Built Construction Report. KM8 Well, Kirby Misperton A Wellsite, North Yorkshire. Envireau Water, June 2017. Ref: P:\Third Energy KMA (1996)\40 - Reporting\PreOp Conditions\PO4\Borehole Construction Report r3.docx
- Ref. 3 KM8 – Hydraulic Fracturing Operation. KM8 Well, Kirby Misperton A Wellsite, North Yorkshire. Envireau Water, November 2015. Ref: P:\Third Energy General (1738)\Fracture Prop\KM8 Frac r4.docx