AQUIND Limited

AQUIND INTERCONNECTOR

Applicant’s Response to the Examining Authority’s Further Written Questions (ExQ2) – Appendix 4 Bentonite Breakout Note (MG2.1.3)

The Infrastructure Planning (Examination Procedure) Rules 2010, Rule 8(1)(b)

The Planning Act 2008

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TECHNICAL INFORMATION NOTE – BENTONITE BREAKOUT

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CONTENTS

1 INTRODUCTION

Please read the entirety of this document to assist with any potential questions related to "drilling fluid".

Further this is a technical note and does not negate or allow the works contractor to abscond from developing appropriate site-specific designs, method statements and risk assessments.

This document is written to provide a high-level view of 'Bentonite' in the trenchless environment.

This Technical Information Note (TIN) is to summarise bentonite drilling fluid, potential risks and subsequent mitigation measures at trenchless crossings on the AQUIND INTERCONNECTOR Project.

For clarity this document also covers the 'HDD2 Allotments' directional drill.

1.1 EXECUTIVE SUMMARY

The risk of bentonite break out at the allotments is small to negligible / minor due to the following reasons:

1. Preliminary design of the directional drills has been conducted to identify suitable depths and lengths of the crossings using a mixture of desk top study's and onsite surveys.
2. Routes which pose a high risk of bentonite break out have been eliminated
3. Designed at a suitable depth in a competent homogenous geological layer.
4. Weaker un-cohesive layers are being cased through to prevent a breakout during the initial shallow stages of the drill

The remainder of the document addresses how the conclusions summarised within the 'Executive Summary were reached.

2 BENTONITE

2.1 WHAT IS BENTONITE

The drilling fluid used during trenchless crossings comprises of bentonite as the primary base (a mined naturally occurring clay1) which is delivered to site as a dried and finely ground powder. This is rehydrated in the temporary mix tank with potable water. In addition to the bentonite, the drilling fluid contains carefully chosen additives to control its rheological properties (See 2.3 / 2.4 for further information).

2.2 CLASSIFICATION OF BENTONITE

Classification Regulation (EC) No 1272/2008: not hazardous

[1] Materials Safety Data Sheet for bentonite can be found in section 7

Classification Directive 67/548/EEC, 1999/45/EC: not classified[2]

2.3 BENTONITE USES

Drilling fluid, a composite made of Bentonite and water has the following functions:

- To remove cuttings from in front of the drill bit
- Power the mud motor
- To transport cuttings from the drill face through the annular space towards the surface
- Lubricate the drill string during drilling phases and HDPE strings during pullback
- Cooling the reamers (cutting tools)
- Hole stabilization
- Creation of a filter cake against the wall of the hole to minimize the risk of loss of drilling fluid or influx of groundwater penetration into the borehole

2.4 BENTONITE CONCENTRATIONS

The characteristics of drilling fluid, especially the viscosity, can be adjusted during the drilling phases by changing the structure of the composite.

The drilling fluid consists of a low concentration bentonite – water mixture. Depending on the formation to be drilled through, the concentration is between 13 litres (30kg) and 35 litres (80kg) of dry bentonite clay per m3 of water.

The use of bentonite has a number of benefits:

- It is a natural material, so no chemicals
- It is recyclable (Holland for example has a long history of using the product as fertilizer)
- It is on the PLONOR[3] list, so discharge onshore or offshore is not a danger to the environment[4]

  [Please see section 7 for an example Materials Safety Data Sheet MSDS]

There is little to no valuable evidence from onshore government bodies regarding the use of bentonite due to the material's non-hazardous label as identified in section 2.2. We therefore reference PLONOR within this document as the list is maintained by CEFAS[5] which is an executive agency of the United Kingdom government Department for Environment, Food and Rural Affairs. This confirms the 'non-hazardous' rating of the product as demonstrated by the MSDS within section 7.

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[2] No labelling regulation as product is not hazardous
[3] PLONOR Poses Little Or No Risk
[4] Discharge is not planned for this project
[5] CEFAS The Centre for Environment, Fisheries and Aquaculture Science

2.5 OTHER DRILLING MATERIALS

The Offshore Chemical Notification Scheme (OCNS) applies to chemicals that are intended for use and discharge in the exploration, exploitation and associated offshore processing of petroleum in the UK and Netherlands.

The scheme is regulated in the UK by the Department for Business, Energy & Industrial Strategy (BEIS) using scientific and environmental advice from CEFAS.

The HDD contractor must ensure that all drilling materials used are CEFAS GOLD (Centre for Environment, Fisheries and Aquaculture Science) rated. This will prevent substitutions and provides a strong baseline for permissible chemicals as they have already undergone rigorous environmental testing.

3 RISK OF BENTONITE BREAKOUT

3.1 BENTONITE LOSS TO SURFACE

Surface breakout most commonly occurs within the first 30m from entry and a competent contractor will avoid this on 90% (Subjective, based on industry experience) of jobs. This is due to the drill being shallow and not yet at the optimum drill depth as identified within the cross-section drawings and detail design.

Specifically, at the HDD-2 Allotments the drill will be entering the 'Bracklesham group' which is indicated by site investigation to be a homogenous and competent geological layer.

The HDD contractor will have a person walking the drill alignment as far as reasonably practicable (within agreed site boundaries) checking for breakout. If detected the drilling is stopped immediately and the spill contained and removed.

Drilling fluid (bentonite) can sometimes break out of the bore in case of highly fissured clay, gravels or where there are large interconnected fissures in the ground. It is good practice to have a stock of ready filled sandbags on site to contain a breakout if it occurs and a small pump with flexible hose to pump the bentonite back to the entry pit.

Breakouts may also occur where man made features are present (e.g. old SI boreholes). In the event of egress of drilling fluid from the bore it is only likely to reach ground level where there is a continuous path available to the surface.

The risk of bentonite break out at the allotments is small to negligible / minor when determined in accordance with a high-level risk register for the directional drills, as required in the CDM 2015 Regulations (Construction Design & Management). The risk assessment method outlines the level of risk, prioritised in accordance with their probability and severity and classified into a risk category of bentonite breakout, not the whole drilling operations.

During drilling, any decrease in the mud volume returning to the entry pit will trigger the need for personnel to closely monitor the area around the drilling head.

A close watching brief during drilling activities and a detailed contingency plan will be deployed to ensure that in the unlikely event of any drilling fluid breakout, the fluid is contained, bunded and pumped back to the entry pit with minimum disturbance to the surrounding environment.

3.2 BENTONITE LOSS TO VOIDS

During drilling in ground with high permeability (e.g. peat) or voids (e.g. chalk) drilling fluid can be lost to the ground. Good ground investigations and good design are the main tools in mitigating this risk for the project. Section 4 of this document sets out detailed mitigation measures advised to be followed in order to prevent a bentonite breakout occurring.

If fluid is lost to the ground the mud man will quickly identify the losses due to the falling fluid levels within their mud tanks. Generally, the mud man will identify any losses greater than 2m3 in volume. Pumping will then be stopped and action taken to seal the area of loss; usually with lost circulation additives.

4 BENTONITE BREAKOUT MITIGATION

4.1 DRILLING PROCEDURE

A key component of avoiding breakout is effective removal of the cuttings from the borehole. If cuttings are not removed they form cuttings beds on the base of the borehole, decreasing the cross sectional area of the borehole. This causes an increase in annular pressure and therefore increases the risk of breakout. Cuttings in the borehole also lead to increased drilling forces and can eventually cause equipment to be lost or stuck downhole.

The HDD contractor will be proactive in ensuring that cuttings are effectively removed and will spend additional time and effort to reduce the risk of both breakout and stuck equipment.

An additional tool that will assist in monitoring the state of the borehole is Downhole Annular Pressure Monitoring. Supplied as a standard add-on to the guidance equipment the tool measures the pressure in the borehole annulus in real-time. The actual value can be compared to limit values calculated from hydro fracture analysis to avoid damaging the ground surrounding the HDD during hole drilling. By avoiding any over-pressuring of the surrounding ground, the probability of surface breakout is remote but conceivable and risk has been controlled as far as reasonably practicable.

Minimising breakout / Frac out impact	
Risk	**Mitigation Measures**
Breakout of drilling fluid to the surface during drilling	Detail design of all trenchless crossings, showing geological layers and intended drill path
	HDD design has sufficient depth below surface for the expected ground conditions
	Hydro fracture analysis and calculation
	Monitoring of drilling fluid returns and volumes to warn of inadequate hole cleaning
	Drilling fluid to be of sufficient viscosity and properties for the ground being drilled
	Real time downhole annular pressure monitoring to warn of over pressurising by drilling fluid (Pressure set by hydro fracture calculation)
	Have lost circulation materials on site to seal any breakout

4.2 SITE MONITORING AND COMMUNICATION

During the construction phase the following onsite communication modes shall be adopted:

Project Communication Modes			
Project Level	**Site Project Meetings (including relevant stakeholders)**		
Work-gang	Daily Toolbox Talks	Health & Safety Inductions	Method Statement Briefings
Individuals	Directly with each employee		'Open door policy'

Drilling mud breakouts are only likely to happen when the fluid is under pressure, so during drilling, site monitoring will be carried out by dedicated, competent and suitably experienced personnel.

The site to be monitored[6] will include an area of 100m in front or behind the drill head and 25m either side of the centre line of the drill route.

The site will be divided into areas which will be checked regularly. Records shall be maintained of inspections.

In addition, a downhole annular pressure sensor will be used during drilling. The maximum allowable annular pressure according to the design calculations will be plotted on the screen within the drilling control cabin with an alarm sounding if annular pressure comes within 90% of that allowable limit.

If the allowable pressure is exceeded, the drilling contractor shall stop drilling and retract the drilling assembly until the blockage has been cleared before continuing to drill.

[6] Area based on high level information, subject to detail design

4.2.1 ANNULAR PRESSURE MONITORING

The HDD contractors design must include a theoretical calculation of hydro fracture for each crossing. This calculation is to be graphed against chainage (distance) and vertical elevation. The graph is to include plotted lines representing the following parameters:

- The topographic surface;
- The vertical bore hole alignment;
- The minimum pressure required to create fluid returns in the entry pit (P_{min});
- The maximum allowable pressure ground could withstand without hydrofracturing (P_{max});
- The Contractor's design must prove that P_{min} will remain lower than P_{max} including a factor of safety.

During the drilling of the pilot hole the Contractor must plot the actual annular pressure on to the theoretical graph mentioned above in real time. The Contractor is to act accordingly if P_{min} approaches P_{max}. Measures such as cleaning the hole, reducing the fluid pressure, reducing the rate of penetration (ROP) should be implemented.

Evidence of calibration of the pressure sub tool shall be submitted to the Clients Representative prior to commencement of the pilot bore or before re-entering the pilot bore if removed.

4.3 SITE REPORTING

The following table provides a list of documents that are to be completed during directional drilling, they all play a role in ensuring the contractor follows best practices which further minimises the risk of bentonite break out.

Detail design shall dictate which of the documents identified as if required (If Rqd') become a requirement and the contract shall dictate the handover / frequency of reporting details.

HDD Record / Report	Included Information	Handover Frequency / Details
Rig Log (Pilot, Reaming and Conditioning)	Rod time, torque and carriage forces. Geology and fluid comments (returns / losses).	By noon the next day.
Steering Log	Azimuth, length and inclination. 3 & 10 joint checks. Position to be referenced to the designed alignment.	By noon the next day.
Rate of Penetration Chart (ROP)	Rod cutting time. Face time. Rig gear / forces. Bit size.	By noon the next day.
Annular Pressure Graph	P_{min}, P_{max} and P_{actual}. Bore profile, ground level.	By noon the next day.
Pipe Pull Back Logs (Casing and Carrier)	Rod time, torque and carriage forces. Fluid comments.	By noon the next day.

Filling and Pre-Hydro Test Logs	Water quantity, times and pressure.	By noon the next day.
Grouting Logs (If Rqd')	Grout quantity, times and pressure.	By noon the next day.
Plotted Pilot Hole AsBuilt (real time)	Plotted as-built bore path relative to the designed and planned bore path.	By noon the next day.
Welding Logs	Welder, weld type, number, date, if tested and rods used.	By noon the next day.
Resources	Details of plant materials and labour	By noon the next day.
Settlement Logs (If Rqd')	Details of settlement or heave along the HDD alignment.	Weekly

5 LOST CIRCULATION MATERIALS

Lost circulation is the loss of drilling fluid from the borehole through cracks, crevices, or porous formations to surface or voids and is referred to in the industry as a 'breakout'. It can be partial or complete, depending on the conditions. Lost circulation is sometimes referred to as lost returns, either partial or complete, because part or all of the fluid fails to return to the surface. When circulation is lost, the drilling fluid is not performing one of its major functions, that of transporting the cuttings up the hole where they can be released in the mud tank or pit. If the cuttings are not removed from the hole, they will pack around the drill string above the bit, resulting in stuck pipe and possible loss of the bit, collars, part of the string and perhaps, the hole.

Lost circulation is probably the most important problem encountered in drilling. It results in:

1. loss of expensive fluid components,
2. loss of drilling time
3. use of potentially expensive lost circulation materials

Most industry experts agree that probably one-half of the lost circulation problems can be avoided and many are driller induced. Proper planning and rig operation are important.

The route of all the directional drills has been carefully selected to ensure it is suitable for the trenchless methodology of directional drilling.

Calculations have been conducted to select a rig size to minimise the annular pressure that causes frac outs at surface.

6 BENTONITE BREAKOUT CLEAN UP

The drilling contractor shall develop and produce a detailed bentonite breakout plan / methodology. The breakout plan shall be specific to each crossing, and it is good practice to follow the below generic methodology.

6.1 BENTONITE BREAKOUT MATERIALS

The drilling contractor onsite shall have available at all times:

1. Silt fencing
2. 4” mobile suction pump, or similar
3. Seal pups (Industry brand name for large sausage shaped containment and absorption pad) or similar
4. Straw bales or similar
5. Timber stakes or similar
6. Sand bags or similar
7. Small tools for erecting temporary bunds

6.2 CLEAN UP SEQUENCING

The following sequence can be used as a guide to outline the clean-up until the site-specific breakout plans are developed by the trenchless contractor[7]:

1. Once the break out / frac out location has been identified the priority is personal safety and then containment.
2. The drilling activity will be immediately stopped – therefore the fluid decreases in pressure, stopping further fluids migrating to surface.
3. Locate the frac out / break out (15 to 30 minutes)
4. Most surface breakouts are quantifiable in litres of fluid and contained using straw bales and silt fencing to contain the fluid (15 to 30 minutes)
5. The drill fluid is then covered with absorbent granules to increase the viscosity to enable the drilling fluid to become a thick clay that can be removed from surface (15 minutes)
6. All of the drilling fluid at surface level can and will be removed back to the drilling compound (60 minutes)
7. In the extremely unlikely (due to prior planning as identified above) event of a larger break out quantifiable by cubic metres of fluid, the priority is always containment.
8. Containment is by the use of silt fencing and straw bales (30 to 60 minutes)
9. Due to the larger volume of fluid to recover a vacuum tanker, or suction pump and hose may be utilised to remove the fluid off the ground. (8 hrs)
10. Remaining deposits would be cleaned and removed from site by hand (60 minutes)

6.3 SPECIFIC CONSTRAINTS TO HDD2 ALLOTMENTS

At HDD2 where it passes under the allotments it has been identified during consultations to prohibit vehicular access at all times.

In the instance of a small breakout, the clean up operation can be done utilising personnel, wheelbarrows and hand held equipment. Should the breakout be larger, the clean up would utilise pumps located outside and or inside the allotment boundary, depending on the location within the allotments with hoses laid by hand to the location of the breakout.

Due to the rheological nature of bentonite, it is possible to remove all trace of the fluid, this is especially important to the project at HDD2 where the drill passes under the allotments:

All surface bentonite shall be removed leaving no visible sign of the bentonite material, and any damage to crop growing in the area would be minimal (a few square metres). Crop that is visibly coated with bentonite may be removed to ensure compliance with the project stance of leaving no visible trace of a breakout.

[7] Durations provided in this section are based on information currently available and existing high-level design

However, if preferred by the allotment holder to reduce unnecessary waste into the environment a quick rinse with water is all that is required prior to consumption.

Should the allotment holder wish to use the bentonite as a fertilizer this is also an option that can be investigated further in the unlikely event of a break out.

This would minimise the number of personnel from the HDD contractors clean up team having to enter the area and also benefit the ground with added nutrients. In this instance it is recommended to spread the bentonite by rake and work into the soil structure.

It is recommended that the above options are used primarily and if specifically requested by the allotment owner/holder that the top 400mm of soil be removed and replaced with the same or higher quality top soil.

7 EXAMPLE BENTONITE MATERIALS SAFETY DATA SHEET

MSDS

CLEAR SOLUTIONS
Performance Drilling Products
The Earth Can Trust

PRODUCT NAME: Ultrabore®

Safety Data Sheet No: 5002EC

1. Identification of the Substances and Details of the Company

Product Description: Drilling Fluid Additive
Company Name and Address:
Clear Solutions International Ltd
Unit B3, Wem Industrial Estate
Soulton Road
Wem
Shropshire SY4 5SD
UK

Date Prepared: August 2009
Issue No: 3
Date Reviewed: March 2016

Tel: +44 (0) 1939 235754
Fax: +44 (0) 1939 232399
Email: info@drilling-products.com

2. Hazards Identification

Classification of the substance
Classification Regulation (EC) No 1272/2008: not hazardous
Classification Directive 67/548/EEC, 1999/45/EC: not classified

Label elements
Labeling Regulation (EC) No 1272/2008: not classified

Other hazards
Not applicable

3. Composition/Information on Ingredients

Substances
Chemical nature: Naturally occurring mineral
CAS No. 1302-78-9
Consists mainly of montmorillinite with < 10% accessory minerals (quartz, feldspar, mica and calcite). Respirable Crystalline Silica (<7.1μ) may be present at <1% and therefore not classified as hazardous.

4. First Aid Measures

Skin Contact: Rinse thoroughly with cold water and seek medical attention if symptoms persist.
Eye Contact: Rinse thoroughly with cold water and seek medical attention if symptoms persist.
Inhalation: Remove person to fresh air, and if symptoms persist seek medical attention.
Ingestion: Drink several glasses of water or milk. If large quantities are ingested seek medical attention.

5. Fire Fighting Measures

Non combustible - when extinguishing fires bear in mind product becomes slippery when wet.

Clear Solutions Group of Companies
Unit B3, Wem Industrial Estate, Soulton Road, Wem, Shropshire SY4 5SD United Kingdom
T +44 (0) 1939 235 754 F +44 (0) 1939 232 399 E info@drilling-products.com W www.drilling-products.com

MSDS

PRODUCT NAME: Ultrabore®

Safety Data Sheet No: 5002EC

6. Accidental Release Measures

Personal precautions: Do not breathe dust – see section 8. Becomes slippery when wet.
Environmental risk: Non-toxic.
Cleaning up: Sweep or vacuum up and dispose of as non-toxic waste.

7. Handling and Storage

Handling: Avoid the creation of dust, and ensure adequate ventilation at point of use. See section 8.
Storage: Store in clean, dry environment.

8. Exposure Controls/Personal Protection

Hand Protection: Use barrier creams and rubber gloves as required.
Skin Protection: Normal work wear.
Respiratory Protection: Use dust masks. Ensure adequate ventilation and dust control measures to maintain dust levels below OES* limit.
*OES level (Occupational Exposure Standard): Dry bentonite is classed as a nuisance dust with an 8 hour TWA for total dust inhalation of 10mg/m^3 and 5 mg/m^3 for respirable dust. Quartz present in small quantities in this product has a Maximum Exposure Limit (MEL) of 0.4mg/m^3 respirable dust for an 8 hour TWA period. (Respirable dust is that portion with a particle size <7.1μ).
Eye protection: Wear safety glasses.

9. Physical and Chemical Properties

Appearance:	Light grey to off-white powder
Odour:	Odourless
pH – 2% suspension:	7 – 9.5
S.G:	2.5
Solubility:	Forms suspension in water
Decomposition Temperature:	Not Evaluated
Flammability:	Non-flammable
Explosive properties:	None
Vapour pressure:	N/A
Flash point:	N/A
Melting point:	N/A
Boiling point:	N/A

10. Stability and Reactivity

Conditions to avoid: Avoid generation of dust. Slippery when wet.
Materials to avoid: Oxidising agents.
Hazardous Decomposition Products: None.

11. Toxicological Information

Ingestion: Orally non-toxic.