APPEAL REF. APP/Z/6950/A/11/2167112/WF

# Appeal by Coastal Oil and Gas Limited

## Site at Unit 1, Llandow Industrial Estate, Cowbridge, CF31 3SH

## Proof Of Evidence Of Oliver Taylor BSc, MSc, FGS, DIC


Summary

Coastal Oil and Gas Limited propose to drill a borehole to explore for the potential of Hydrocarbons in Llandow Industrial Estate. The initial planning application was rejected on grounds of potential disturbance to the ground water.

From the geological model developed by Coastal Oil and Gas Limited a structural high has been identified in the strata below Llandow this suggests that a potential trap for conventional hydrocarbons may exist in the Devonian Sandstones and Coastal Oil and Gas Limited require planning permission to drill this target. The lower limestone shales would be sampled and tested as a part of the drilling operation.

An investigation of the local geology and hydrology has been undertaken to compile the geological model. Additional work has been conducted to look at the detailed geology and ground water in the Vale of Glamorgan. This indicates that:-

- The distance to the nearest public water supply is over 7.8km from the Llandow site
- The geology between the proposed site and the nearest public water supply is folded and faulted to extremely reduce the potential pathway from the proposed site to the nearest public water supply. Therefore the potential for the drilling fluids to enter the public water supply is none.
- The pathway for fluids to flow in the limestones is generally along faults and not through the body of the limestone. At depths greater that 100m there is not expected to be any ground water flow.
- The location of private water supplies is not in the public record and Coastal Oil and Gas Limited have only been notified of one approximately 1 mile to the north. There are no know faults linking the site to this area. If a hydrologic gradient exists (which is unlikely) it would take between 300-15,000days to reach a private supply 1500m from the borehole.
- Within a 1km radius of the borehole the local limestone at a porosity of 2%-0.5% contains between 7.8-31.4 million cubic metres. The $20m^3$ of fluids in the closed loop system of the borehole would represent 0.00025%-0.00000064% of the volume of fluid in this area.

- The method of drilling would seal off the surface water and near surface ground water within 2-3 days of starting the drilling process. The borehole would then be lined with steel and cement to prevent any fluid losses into these formations.

- Following the drilling of the limestones the borehole would again be sealed with steel and cement. This would seal the borehole to prevent any fluid losses into the limestones whilst the drilling continues.

- The volume of drilling fluid on site would be approximately $20m^3$. The drilling fluids will be constantly monitored during the drilling.

- The proposed drilling fluid (Purebore) is non-toxic and breaks down completely in ground water. Upon completion of the drilling any excess fluids will be removed from site to a licenced waste disposal facility.

- When the drilling and testing is completed the borehole will be de commissioned in accordance with the Environment Agency advice.

Appellant
Mr O.Taylor
No of Statement: 1st
Dated: April 2012

**IN THE MATTER OF LLANDOW INDUSTRIAL ESTATE**
**AND IN THE MATTER OF AN APPLICATION MADE UNDER SECTION 78 THE TOWN AND COUNTRY PLANNING ACT 1990 AND TOWN AND COUNTRY PLANNING (GENERAL DEVELOPMENT PROCEEDURE) ORDER 1995**
**APPEAL REFERENCE APP/Z/6950/A/11/2167112/WF**

B E T W E E N

COASTAL OIL AND GAS LIMITED

Appellants

And

VALE OF GLAMORGAN COUNTY COUNCIL

Respondent

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# WITNESS STATEMENT OF MR OLIVER TAYLOR

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1 I work as a consultant geologist for Coastal Oil and Gas ("Coastal"). I have my own consultancy firm, Oliver Taylor Geological Consultancy. I have been retained by Coastal as a consultant geologist since 2005. I take my instructions directly from Gerwyn Williams managing director of Coastal.

2 Prior to consulting to Coastal I worked as a geologist for a number of onshore oil and gas companies including Octagon Energy Limited on several coal bed methane projects in the UK.

3 I hold a BSc in Geology (from Cardiff University) and an MSc in Applied Structural Geology and Rock Mechanics (from Imperial College London). I am also a fellow of the Geological Society (FGS).

4 I make this witness statement on behalf of the appellant and in support of the appeal on the decision to reject the planning application ref: APP/Z/6950/A/11/2167112/WF. In respect of

the refusal to drill and test the insitu lower limestone and associated strata for the presence of gas at Unit 1, Llandow Industrial Estate, Cowbridge, CF31 3SH

## 5 Background

5.1 Coastal owns a 50% share of a number of Petroleum Exploration and Development Licence (PEDL) in South Wales. Adamo Energy (UK) Limited holds the other 50% share. Coastal is approved as an operator for this licence by the Crown. This licence allows for the exploration, testing and extraction of hydrocarbons over a 1,060sq km block of land in South Wales

## 5 Appellants Case

5.1 Reasons for drilling the borehole. As part of the on-going hydrocarbon exploration on the licence areas, a geological model has been created for the three PEDL licences in the Vale of Glamorgan. The geological model has been created using the available geological information from British Geological Survey (BGS) surface mapping, published cross sections and 3 seismic lines that were shot by Shell in the 1980's.

5.2 The geological model indicates a structural high (anticline) around the Llandow Industrial Estate. The proposed borehole in Llandow has been located on the possible structural high in the strata that may form a conventional sandstone gas reservoir in the Devonian Old Red Sandstone. The main object of this borehole is to look for the presence of natural gas in the Devonian Sandstones reservoirs below the Lower Limestone Shale that if present would not need any stimulation to recover the gas. This gas would be held as a conventional reservoir similar to the North Sea, where the gas has been produced then migrated to the anticline where it is trapped by the impermeable shales above. Drilling this target is the only way to detect weather the gas is present. As part of this exploration samples of the lower limestone shale will be obtained and tested.

## 6 Geology

6.1 The underlying geology that has been published by the BGS shows that between the proposed site in Llandow and the Schwyll extraction point there is a faulted anticline (an area where the rocks have been folded and broken by large tectonic forces). The cross section that is published in the Bridgend Sheet 262 is parallel to the line between Llandow and Schwyll around 2Km west. (See Figure 2)


Line of cross section (below)

Line of Schwyll Catchement – Taken from EA Report

Faults at Surface

Coast Line

Out Line of PEDL Licences

**Figure 1 – Location of Schwyll Catchement in relation to surface faults and the proposed site in Llandow**

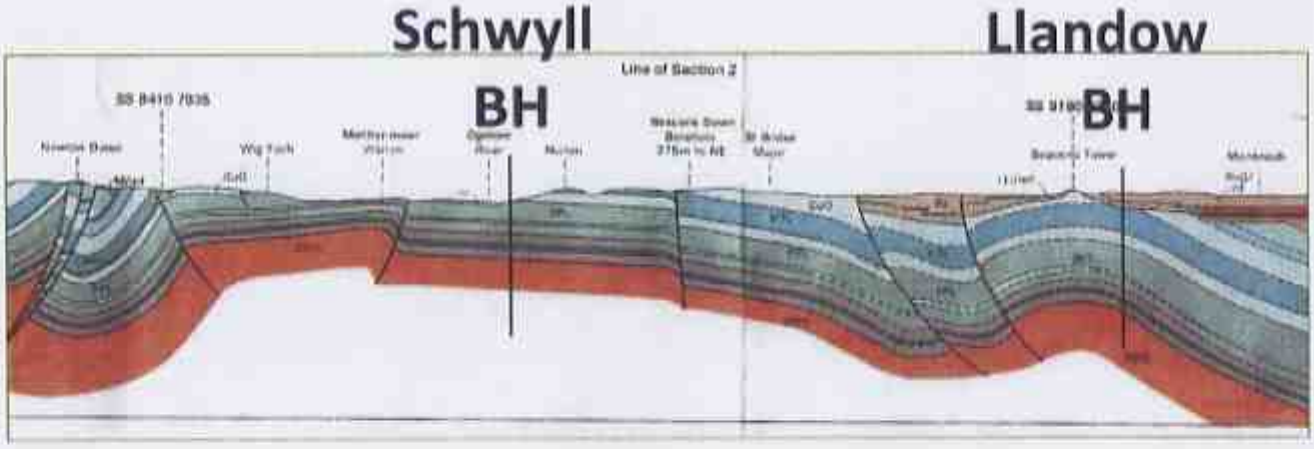


**Figure 2 – Geological Cross section (Published by the British Geological Survey)**

6.2 The cross section above (Figure 2) shows the locations of the proposed site in Llandow and the water extraction point at Schwyll and the relationship of the geological formations and faults between them. The surface geology at the Schwyll extraction point is the Black Rock Limestone group that is around 300m thick, with the Friars Point Limestone (FPL on figure 2) as part of this group (See Appendix 1 for the detailed stratigraphy). Between Schwyll and Llandow the geology generally dips to the south then up and over a large Anticline. At the surface in Llandow there are Jurassic aged rocks of the Porthkerry Formation these rest

uncomformably on the Carboniferous Limestones. The main target for the exploration in the Llandow borehole is the Cwmyniscoy Mudstone in the Lower Limestone Shale Formation, and the Devonian Old Red Sandstones.

6.3 The BGS states that several major tectonic episodes have affected South Wales since the Late Devonian. The most significant of these in terms of the local area is the Variscan deformation which occurred towards the end of the Carboniferous some 300-280 million years ago. This deformation folded and fractured the ground to give rise to the anticlines and faults that are seen today.

6.4 Between the drilling site in Llandow and the Schwyll catchment there are sub parallel NNE-SSW trending Normal Faults that are associated with the Variscian folding. At a number of localities these faults are exposed at the surface, they have been described by the BGS and show that the younger Jurassic stratum is down thrown against the Carboniferous Limestones, this indicates that the throw on the faults are substantial and all stratum would be displaced across the fault. In the fault zone there is up to 1.5metres of fault breccia of clays and Carboniferous Limestone, this would act as lower permeability pathways for the groundwater to flow, this suggest that the fluids would flow along the faults and not across the faults.

6.5 The BGS reports that there is a similar trending sequence of faults some further 2-2.5km to the north. This represents an additional barrier to fluid transport.

## 7 Protection of Groundwater

7.1 Environment Agency – As part of the planning application process the Environment Agency is a statutory consultees and they make comments and recommendations on the planning application. Coastal have also had a number of meetings with the Environment Agency to discuss the ongoing projects and the method of drilling and protecting the environment.

7.2 From these discussions and proposals with the Environment Agency there were no outstanding issues. [Core Documents Ref***]

7.3 The Environment Agency have identified that the Carboniferous Limestone is the main water bearing strata (Aquifer) in the area, and is classified by the Environment Agency as a major aquifer. The Carboniferous Limestone is a rock type that formed in a shallow tropical sea around 350 million years ago. Over time the rock forming process greatly reduces, the primary porosity and permeability (ability to allow water to pass through the rock) of the Limestone. Within such an aquifer it is the secondary network of solution-enlarged fractures (conduits) that provide the majority of the water bearing horizons. The circulation of groundwater within the aquifer relies on the interconnectivity of these fractures/conduits. Movement of groundwater can also be enhanced or impeded by tectonic activity, with folding and faulting potentially creating areas of high or low permeability. As Carboniferous Limestone is known to have a low primary porosity, the flow type is likely to be dominated by fracture/fissure flow. Only the uppermost 100m of the aquifer is likely to be effective in transmitting water, below this depth the fractures are likely to become too tight, due to the overburden pressure, to allow water to travel along them. The path of ground water flow is generally along the path of least resistance.

7.4 The properties of the Carboniferous aquifer that have been published by the BGS/EA showed hydraulic conductivity(ability for water to travel through the limestone) estimates

range between 0.1-5m/day but are identified as being overestimates due to partial penetration effects. The effective porosity of the upper 8-10m of the aquifer ranges between 6-8%, reducing to 0.5-2% below this.

7.5 The effective porosity of the limestone is an indication of how much ground water is in the limestones (Not including fractures). On page 7 of the Environment Agency Report [Core Documents Ref***] this states that the porosity is between 0.5-2%, over a 1km radius of the borehole in the 500m thick section of limestones the volume of ground water is expected to be between 7.8-31.4 million cubic metres.

7.6 For the drilling fluids to enter the Schwyll Catchment then the fluids would have to rise over the anticline and then cross a series of faults. This is unlikely to happen as the flow of water from one area to another is dependent on the hydraulic gradient and the fluids are not likely to flow uphill over the anticline or to cross over the fault planes. There are no faults recorded in a direct path between Llandow and Schwyll.

## 8 Public Water supplies

8.1 Following discussions and an exchange of letters with Welsh Water the nearest public supply point is in Bridgend Industrial Estate (SS93400 79600) 7.8km from the proposed borehole at Llandow. The Schwyll (SS88700 77100) boreholes and pumping station is 8.6km from Llandow. Schwyll Spring was for public water supply to abstract water from the Carboniferous Limestone, and are licensed to abstract 7955500$m^3$ per annum, however this site is currently 'mothballed' and is not utilised for supply. [Information based on the Environment Agency – Ref Core Document****]

8.2 The Environment Agency has published a report into the Schwyll Aquifer *'Groundwater Quality Review: Porthcawl – Schwyll Aquifer Unit - Analysis of the Porthcawl – Schwyll Aquifer Unit Groundwater Chemistry'*. This publication discusses the local geology and hydrology of the aquifer and groundwater quality. Maps [Ref Core Document****] indicating the extent of the Schwyll catchments are published along with the report. Analysis of these maps indicates that the Llandow Borehole is over 3.7km from the catchment at the nearest point.

## 9 Private Water Supplies

9.1 Coastal have submitted a request to the Vale of Glamorgan council to request what other boreholes that they have given planning permission for in the past 10 years. Looking through the archive on their website it appears that they have not given permission for any deep drilling.

9.2 From the BGS database the nearest published boreholes are 2.4km and 4.5km from proposed site at Llandow. The Beacon Tower Wick and Llanblethain boreholes were drilled in 1994 drilled by the BGS to test the stratigraphy and quality of water to a depth of 102m and 67m respectively.

9.3 With private water supplies if the drilling has taken place under a General Development Order and is permitted development then no planning permission is required so there is no public record of them. If the owner of the borehole is extracting less than 20$m^3$ per day then they do not require any licence from the Environment Agency and again there is no public record.

9.4 From the letters to the Vale of Glamorgan planning during the application process Mr Davis from Westmoor Farm, Llysworney (approximately 1 mile north of the proposed site, the exact site is not known and from the post code of the address the site could be 3.5km north) states that he has a private water supply for his cattle and sheep. From the published hydraulic conductivity records any fluids would take between 0.1-5m/day to travel through the limestone (there is no recorded fault between the two points) this suggests that the fluids would take 15,000-300 days to reach the farm. The BGS map show that the faults generally trend east west with a large fault some 1.8km north of the site that would generally stop any fluid across the fault plane. From the environmental analysis of the Purebore drilling fluid the polymer would have full degraded by the time it reaches the private water supply.

**10.0 Method of drilling the borehole**

Following the establishment of all the site equipment, this generally arrives on site on one day.

1. Drill and cement surface casing to isolate any shallow groundwater.
2. Drill and set secondary casing to isolate any groundwater.
3. Drill and take cores from selected strata
4. Geophysically log the borehole (Run an electronic sensors through the borehole)
5. Analysis the samples in a laboratory (On site and in Aberdeen)
6. Leave Borehole open for long term production tests or Completely fill the borehole with cement (to prevent migration of any groundwater that may occur)

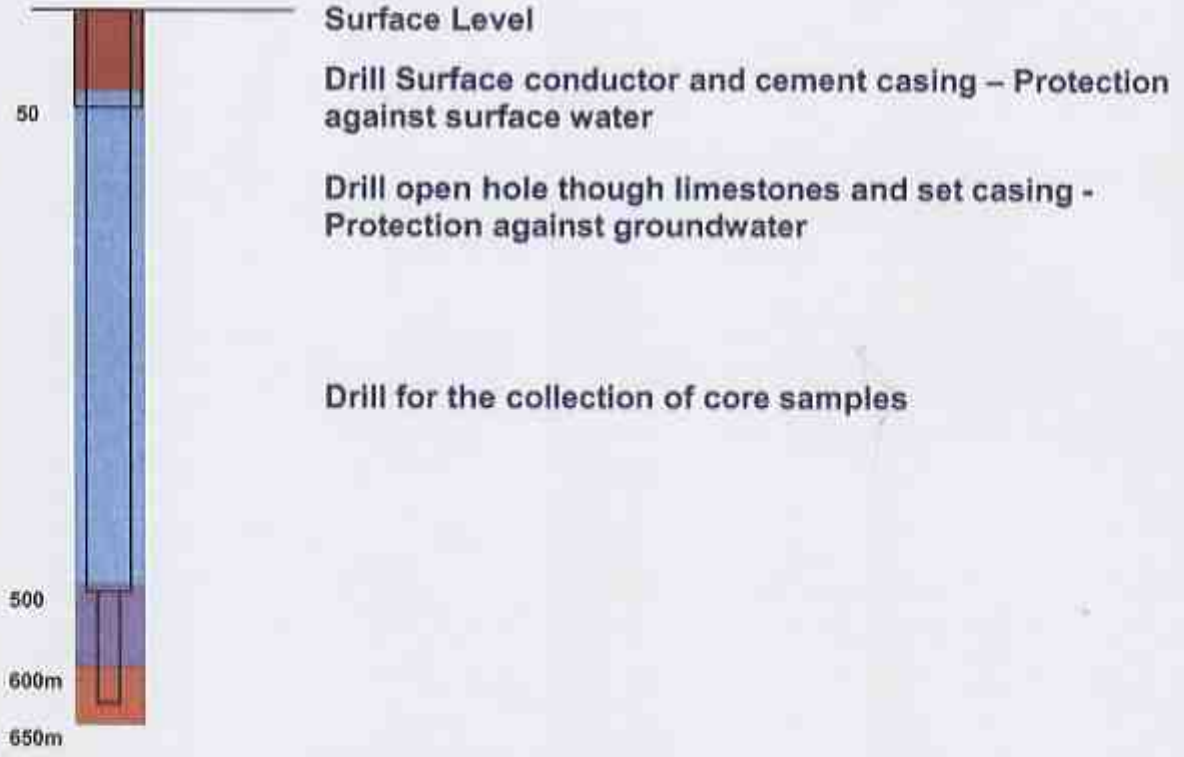


**Figure 3: Section through Proposed Borehole**

10.1 The drilling of the surface casing should only take 2-3 days following the commencement of the drilling. This will seal off any surface water and the near surface groundwater from the borehole. The casing is installed after the initial hole has been drilled to the required depth, then the volume of cement required to fill the annulus between the casing and the borehole wall is pumped through the casing until cement returns around the back of the casing at the surface to ensure a good seal is seen against the casing and the borehole wall. This part of the borehole can be drilled with air as the flushing medium rather than a fluid, this would lift any ground water encountered in the borehole during the drilling. Using Air as the drilling fluid greatly reduces the possibility of contamination of the groundwater. Any water recovered from the borehole would be collected in the tanks and sent off site for disposal to a licensed waste facility.

10.2 Drilling continues through to the base of the limestones at around 500m. The secondary casing is installed in 6m lengths and screw threaded together, the specification of the casing is agreed with the Health and Safety Executive prior to the commencement of the drilling. When the casing is lowered to the base of the borehole the cement is installed by the same method as the surface casing, by pumping through the casing until returns are seen at the surface. The drilling and casing of the secondary casing should be completed in around 7-14 days. Following the completion of the casing installation the drilling fluids would have a permanent barrier of steel and cement against the limestone aquifer.

10.3 At this stage the drilling method would change to allow for a continual sample of the strata to be collected for analysis.

**11 Drilling Fluids**

11.1 There are a number of different drilling fluids on the market. The main purpose of the drilling fluid is to:-

- Act as well control to use the density of the fluid to stop other fluids (water and hydrocarbons) entering the well. The increase in density and therefore weight of the fluid prevents groundwater and any hydrocarbons entering the well in an uncontrolled manor
- Cool the drilling bit as it cuts the rock
- Lift the cuttings to the surface.

Different properties of the drilling fluid can also be used to

- Act to stabilise the borehole walls
- Create a barrier between the borehole wall and drilling fluids this is often described as filter cake.

11.2 The volume of drilling fluid on site will vary with the depth of the borehole, a 150mm diameter borehole at 650m will have a volume of 11.5m$^3$, allowing for volume of fluid in the storage tanks and in pipes there will be around 20m$^3$ of drilling fluids in the closed loop system during the drilling (See Figure 4).

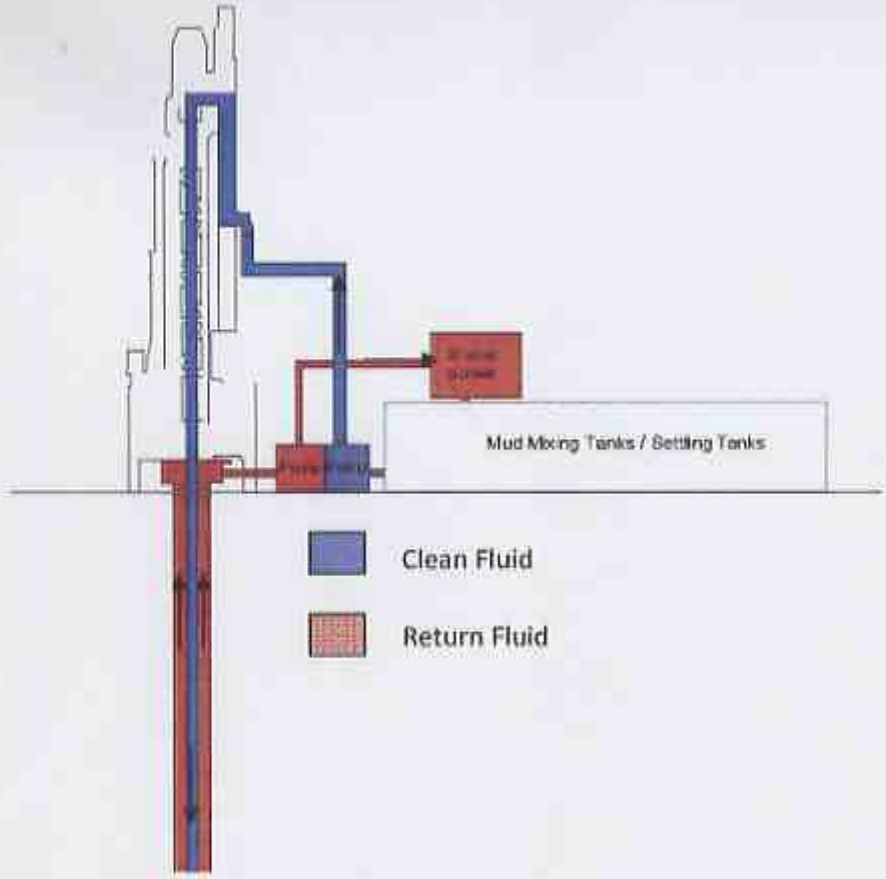


**Figure 4: Close Loop System for the drilling fluids**

11.3 The control of ground water during the drilling of this well will by the density of the drilling fluids which would prevent any major water ingress. The main aquifer has been identified in the Carboniferous Limestone and this will be completely sealed with steel casing cemented into place, this is a recognised method of sealing an aquifer by the Environment Agency. The drilling fluids used are contained in a closed loop system; the volume of fluid required will depend on the depth of the well. The drilling fluid will be held in tanks on the surface so that they can be checked for levels and leaks. The cuttings will be separated from the drilling fluids on shaker screens described below, the drilling fluids are then re-used and re-circulated around the borehole.

- Shaker screen – the drilling fluid is passed over a fine vibrating sieve of various sizes to allow the drill cuttings to pass into a covered skip for disposal and the drilling fluid to drop through and return to the closed loop system. This separates the solid drill cuttings from the fluid so that it can be re-circulated back down the wellbore. In oilfield industry, linear motion shale shakers are widely used.

- At the end of the drilling operation all excess drilling fluid will be tankered off site to a licensed disposal facility.

As all drilling fluids are maintained in a closed loop system this can easily be monitored for leaks. In the event of a loss of fluid to the system then the source of that loss will be investigated. If there is a leak to a tank / pipe then this will be repaired as soon as

practical. The tanks will be placed so that they can be observed by the drilling crew and site staff. In the event that there is an increase in drilling fluid that may allow a spillage from the tanks, drilling will cease until additional tanks can allow for the increase in fluid or the additional fluid is tankered off site to and appropriate facility.

11.4 During the drilling of the borehole the levels of the drilling fluids are constantly monitored by the drilling crew and tests on the fluids are made after the drilling of a drill rod (6m).

The properties tested by the drill crew are

- Density of the fluid
- Viscosity of the fluid
- Colour of the fluid

Tested 2-3 times per shift

- Sand Content of the fluid

11.4 During the drilling the levels in the tanks are observed by the drilling and site crew. If there are any losses of drilling fluids, seen in the tanks, then drilling will cease as soon as practicable to assess where the fluids are being lost into the borehole, this is generally straight away. When drilling through the limestones any fluid losses will generally be through fracture zones, when the confining pressure allows the fluids to flow into the formation. There are a number of ways to reduce the loss of fluids in the borehole.

- Lost circulation material that is similar to the material seen in babies nappies that can be pumped into a fracture this then swells and seals of the fracture from fluid losses, walnut shell casing can also be used to block fractures.
- If the fluid losses cannot be contained using lost circulation material an additional section steel casing and cement could be installed to form a barrier between the fractures and the borehole.

11.5 Given that the volume of potential groundwater in a 1km radius of the borehole is between 7.8-31.4 million cubic metres, the loss of $20m^3$ into the groundwater would account for 0.00025% of the volume of fluid in a 1km radius.

5.2 11.6 During the correspondence with Welsh Water, Coastal were asked which drilling fluids would be used. The selection of drilling fluids is generally down to the drilling contractor. Coastal provided the details of a product called Purebore made by Clear Solutions International Limited. Purebore is a biopolymer which according to the manufacture should biodegrade in 8-52 weeks; it is stored as a powder and mixed on site with water to form the drilling fluid. (Appendix 2) is the Datasheet for Pure Bore, and environmental report undertaken by EnviroInnovate (Appendix 3) and a press release for a 3000m borehole drilled under Milford Haven using Purebore (Appendix 4). Purebore has recently been accredited by Cefas - the Centre for Environment, Fisheries and Aquaculture Science (Part of DEFRA) to be used in the marine environment (Appendix 5).

11.5 The storage of drilling fluids, prior to mixing the drilling fluids are in powder form in bags. These will be stored in the drilling store shown on the site layout plan.

11.6 Control of surface water will be affected by a constructing a single block wall around the site and installing an inceptor tank. Waste water will be tankered off site to a licensed disposal site.

11.7 The storage of all oils and Fuels will be within a bunded fuel tank where the volume of the bund is 1.5 times the capacity of the tank. During fuel transfer absorbent matting will be placed below the fuel fill point to catch any drips. Drip trays lined with absorbent matting will be placed under the drilling rig at all times.

11.8 Foul sewage will be from the site toilet; this will be a hired 'portaloo' type and will be emptied weekly by a licensed operator.

## 12 Decommissioning the borehole

12.1 The Environment Agency has published advice and guidance for the Decommissioning Redundant Boreholes and Wells. This sets out the scope and legal framework for the decommissioning of borehole under the Water Resources Act 1991. [Core Documents Ref:***] This states '*Boreholes and wells that are no longer required therefore need to be made safe, structurally stable and backfilled or sealed to prevent groundwater pollution and flow of water between different aquifer units.* '. This process is managed by completely filling the borehole with a similar density material that was removed i.e. cement.

12.2 The report states '***The following objectives may apply, although additional objectives may also be applicable;***

- *Remove the hazard of an open hole (safety issues).*
- *Prevent the borehole acting as a conduit for contamination to enter groundwater.*
- *Prevent the mixing of contaminated and uncontaminated groundwater from different aquifers.*
- *Prevent the flow of groundwater from one geological horizon to another.*
- *Prevent the wastage of groundwater from overflow to artesian boreholes.*

*The method of decommissioning should be capable of achieving each of the objectives that are applicable to a site.*

These principles have been followed by Coastal Oil and Gas Limited on other sites and will continue to be followed for the decommissioning of future boreholes.

12.3 Upon completion of the drilling and testing, the borehole will be completely filled with cement in accordance with the recommendations set out by the Environment Agency guidelines. Cement will be mixed on the surface in a grout mixer then pumped to the base of the borehole via a tremmy pipe. The tremmy pipe will be lifted out of the borehole in stages and more cement will be pumped into the borehole. The volume of the borehole will be confirmed by the results of the geophysical logging. The casing that has been cemented in place in the limestones will be left in situ. The multi stage filling will ensure that the borehole is completely filled. The cement will have similar density to the surrounding rock. The filling of the borehole will seal the hole to stop the vertical migration of groundwater.

## 13 Surface Water Protection

13.1 Control of surface water will be affected by a constructing a single block wall around the site and installing an inceptor tank. Waste water will be tankered off site to a licensed disposal site. Under the operating plant and machinery a 'drip tray' will be used to collect any oil drips from the working parts' The propose of the bund and interceptor tank is generally to control any surface water in the form of rain leaving the site during the drilling and testing.

**14. Conclusion**

Given the above and from the understanding of the local geology and hydrology I believe that Coastal has taken sufficient measures to prevent the contamination of groundwater during the drilling of this exploration borehole

I believe the contents of the statement to be true

Signed .....

Mr Oliver Taylor

Dated this the day of April 2012

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**B E T W E E N**

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**Appendix 1**

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**Appendix 1**

| Geological Era | Formation | | Lithology |
|---|---|---|---|
| Quaternary | Blown Sand | | Blown Sand |
| Unconformity | | | |
| Jurassic | Lower Lias | Marginal Facies | Conglomerates, calcarenites, oolitic, peloidal and bioclastic limestones |
| | | Porthkerry Formation | Thinly interbedded grey limestones and calcareous mudstones |
| | | Lavernock Shales | Dark grey mudstones with subordinate limestones |
| | | St Mary's Well Bay Fm | Thinly interbedded grey limestones and calcareousmudstones |
| Triassic | Penarth Group | Undivided | Grey-green calcareous mudstones overlying dark grey mudstones, thin sandstones, limestones and oolites |
| | | Marginal Facies | Red, purple and green mudstones with calcretes overlying sandstones and sandy limestones |
| | Mercia Mudstone Group | Blue Anchor Fm | Grey-green mudstones with subordinate dolomites, limestone and evaporites |
| | | Undivided | Red-brown mudstones with some siltstones and evaporites |
| | | Marginal Facies | Red and grey breccias, conglomerates, calcarenites and siltstones |
| Unconformity | | | |
| Carboniferous | Millstone Grit | | Grey mudstones, coarse pebbly sandstones, siltstones and cherts |
| | Carboniferous Limestone Supergroup | | Oystermouth Beds | Thinly interbedded limestones, mudstones & cherts |
| | | | Oxwich Head Limestone | Thick bedded limestone, pseudobrecciation and palaeokarsts |
| | | Hunts Bay Oolite Group | Stormy Limestone Fm | Calcitic mudstones, bioclastic, oolitic, stromatolitic and oncolitic limestones |
| | | | Cornelly Oolite Fm | Oolitic, bioclastic, peloidal and intraclast limestones |
| | | | High Tor | Bioclastic and pelodial limestone |

| | | | | |
|---|---|---|---|---|
| | | | Limestone | |
| | | | Caswell Bay Mudstone | Calcite mudstones & argillaceous limestones |
| | | | Gully Oolite | Thick bedded oolitic, bioclastic and peloidal limestone |
| | | Black Rock Limestone Group | Friars Point Limestone | Dark grey, foetid bioclastic limestone with shale partings |
| | | | Brofiscin Oolite | Pale grey, oolitic limestones |
| | | | Barry Harbour Limestone | Thinly bedded biolclastic limestones and mudstones |
| | | | Cwmyniscoy Mudstone | Grey silty mudstones with thin agrillaceous bioclastic limestones |
| | | | Castell Coch Limestone | Coarse bioclastic limestones |
| | | | Tongwynlais Fm | Mudstones and bioclastic limestones |
| Devonian | Old Red Sandstones | | | Red-brown sandstones, siltstones and mudstones |

**Appendix 1: Geological succession in the area between Llandow and Schwyll**

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**Appendix 2**

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# Pure-Bore®

THE DRILLING FLUID FOR A CLEANER TOMORROW

| | |
|---|---|
| | Pure-Bore® is a natural biodegradable drilling fluid, which can be used in a wide variety of drilling applications. Specially produced, dry free flowing polymer, Pure-Bore® provides exceptional bore hole stability and cuttings removal in a wide range of ground conditions. |
| | Biodegradable drilling fluid.<br>Effective in all ground conditions (one sack drilling fluid).<br>High viscosity for efficient hole cleaning.<br>High yield point and gel strength for maximum cuttings suspension and transport.<br>Generates a tight filter cake and provides exceptional bore hole stability in unconsolidated formations.<br>Provides clay and shale inhibition.<br>Minimises formation damage.<br>Maximises production rates.<br>Can be cleaned down through regular de-sanders. |
| | Environmentally friendly, non-toxic drilling fluid.<br>Fast and efficient mixing in salt or fresh water.<br>Stable whilst drilling.<br>Recycles through standard de-sanding/de-silting equipment.<br>Minimises formation damage for improved well development.<br>Better formation samples.<br>Reduced swelling clay problems<br>Reduced abrasive wear<br>Increased penetration rate<br>Reduced power / fuel costs<br>3 Kilos of Pure-Bore® provides the same viscosity as 60 Kilos of civil engineering grade bentonite or 20 Kilos of high yield bentonite<br>Naturally biodegrades (stabiliser can be added to retard biodegradation)<br>Can be chemically destroyed with calcium hypochlorite<br>Low cost slurry disposal. Destroy or Biodegrade the Pure-Bore® polymer to settle out drilled cuttings in a settlement pit. The fluid phase can then be treated at a sewage treatment works leaving semi dry cuttings |
| | Add slowly and uniformly through a high-shear venturi type hopper. Continue to agitate/circulate until Pure-Bore® is fully dispersed |

| | kg/M3 | lbs/100 US Gal |
|---|---|---|
| Consolidated Formation (Clay/Shale) | 2 – 4 kg's | 1.6 – 3.3 lbs |
| Unconsolidated Formation (Sand/Gravel) | 3 - 7 kg's | 2.4 – 5.6 lbs |
| Calcium hypochlorite (65% active) | 1 – 3 kg's | 0.8 – 2.5 lbs |

| | |
|---|---|
| | Pure-Bore® is packaged in 5kg plastic bags (5 x 5kg bags per cardboard case) |

*The information and data contained herein are believed to be accurate and reliable. Clear Solutions International Limited makes no warranty of any kind and accepts no responsibility for the results obtained through application of this information.*

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DRILLING PRODUCTS FOR THE FUTURE

IN THE MATTER OF LLANDOW INDUSTRIAL ESTATE
AND IN THE MATTER OF AN APPLICATION MADE UNDER SECTION 78 THE TOWN AND COUNTRY PLANNING ACT 1990 AND TOWN AND COUNTRY PLANNING (GENERAL DEVELOPMENT PROCEEDURE) ORDER 1995
APPEAL REFERENCE APP/Z/6950/A/11/2167112/WF

**B E T W E E N**

**COASTAL OIL AND GAS LIMITED**

**Appellants**

**And**

**VALE OF GLAMORGAN COUNTY COUNCIL**

**Respondent**

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**Appendix 3**

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# PURE-BORE

## Chemical Analysis

A Technical Scoping Study of 5 days duration was undertaken by EnviroInnovate to investigate the potential toxicity and environmental impacts of PURE-BORE drilling fluid. PURE-BORE is composed of biopolymer, which biodegrades within 8 to 52 weeks.

Several analytical techniques were used to determine the main elemental and anionic composition of the drilling fluid.

The main findings of this investigation are as follows:

1. Five-Day Biochemical Oxygen Demand ($BOD_5$) can be considered relatively high with $BOD_5$ values measured at 9 mg/l and 36 mg/l for a 1:10000 and a 1:1000 dilution of PURE-BORE, respectively. However, these $BOD_5$ values are comparable with wastewater often discharged into surface waters.

2. X-Ray fluorescence spectroscopy (XRF) and inductively coupled plasma atomic emission spectrometry (ICP-AES) recorded low concentrations for the majority of the elements that were analysed. Sodium and calcium are present in relatively large quantities when compared to the other elements that were measured, but can still be considered to be present at very low concentrations.

3. Ion chromatography (IC) recorded low concentration for fluoride, bromide and sulphate but recorded a noticeably greater concentration of chloride (15.1 ppm). However, all of the anions can be considered to be present at very low concentrations.

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4. Eco-toxicology was assessed using juvenile Daphnia Magna. As a 1:10000 dilution toxicity was minimal and is indistinguishable from the degree of error involved in the test. A dilution of 1:1000 showed a degree of toxicity after 48 hours, with 42% of the organisms being immobile.

## 2. Methods of analysis

The laboratory methods used in the analysis of PURE-BORE are described under the appropriate headings. For chemical analysis appropriate standards were used throughout.

### X-Ray Fluorescence spectroscopy

X-Ray fluorescence spectroscopy analyses non liquid samples, therefore, analysis could be undertaken on the PURE-BORE powder directly without requiring dilution with water or acids. The PURE-BORE sample was passed through the system after being prepared by a method standard to this type of instrument. The analysis was repeated three times and the average value for each analyte was calculated. The appropriate standards were used in the calibration of the equipment.

### Ion Chromatography

A Dionex Ion Chromatograph Model DX-100 was used to measure all the major anions. A 1:1000 dilution of PURE-BORE was prepared with ultra pure water and then passed through the

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chromatograph. The analysis was repeated three times and the average value for each analyte was calculated. The appropriate standards were used in the calibration of the equipment.

## Inductively Coupled Plasma Atomic Emission Spectrometry

A 1:1000 dilution of PURE-BORE was prepared with ultra pure water and then passed through the spectrometer. This was repeated three times and the average value for each analyte was calculated. The appropriate standards were used in the calibration of the equipment.

## Biochemical Oxygen Demand

An 'Oxitop' kit was used to determine $BOD_5$ for PURE-BORE dilutions of 1:1000 and 1:10,000. The 'Oxitop' system is a standard respiration test that utilises changes in pressure, within the Oxitiop bottle, to determine the $BOD_5$.

## Eco-toxicology

The test was based on a method derived by the Environment Agency from the BSI method BS6068, Part 5: Section 5.1. The test is designed to investigate the toxic effect of substances on the swimming capabilities of juvenile *Daphnia magna*. In this case, groups of juvenile daphnids were exposed to the PURE-BORE solutions for a period of 48 hours under controlled laboratory conditions (pH 6.0 to 8.5, dissolved oxygen > 60% ASV, hardness 80 to 320 mg/l, temperature 20 ± 2°C).

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At the end of this time period, the number of immobile daphnids out of a test population of 100 was counted by optical microscopy. The test defines immobilisation as 'juvenile *Daphnia magna* that do not actively swim within 15 seconds of gentle agitation of the test vessel'. Swimming is taken as an indicator of survival in the environment.

Two concentrations of PURE-BORE were used in this test – a 1:1,000 solution and a 1:10,000 solution.

## 3. Results

### X-Ray Fluorescence spectroscopy

| Element | Symbol | Concentration (%) | Abs. Error (%) |
|---|---|---|---|
| Sodium | Na | 0.748 | 0.05 |
| Magnesium | Mg | 0.0395 | 0.0031 |
| Aluminium | Al | <0.0031 | 0 |
| Silicon | Si | 0.00607 | 0.00067 |
| Phosphorous | P | 0.04203 | 0.00042 |
| Sulphur | Si | 0.02439 | 0.00021 |
| Chlorine | Cl | 0.3179 | 0.0005 |
| Potassium | K | 0.0676 | 0.0011 |
| Calcium | Ca | 0.6165 | 0.0022 |
| Titanium | Ti | <0.00012 | 0 |
| Vanadium | V | <0.00015 | 0 |
| Chromium | Cr | <0.00055 | 0 |
| Manganese | Mn | <0.0004 | 0 |
| Iron | Fe | 0.00538 | 0.00023 |
| Cobalt | Co | <0.00015 | 0 |
| Nickel | Ni | <0.0001 | 0 |
| Copper | Cu | 0.00015 | 0.00005 |
| Zinc | Zn | 0.0011 | 0.00004 |
| Arsenic | As | <0.00003 | 0.00002 |
| Selenium | Se | 0.00004 | 0.00002 |
| Rubidium | Rb | <0.0003 | 0.00006 |
| Strontium | Sr | 0.00116 | 0.00003 |

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| | | | |
|---|---|---|---|
| Zirconium | Zr | <0.05 | 0.036 |
| Molybdenum | Mo | <0.0013 | 0 |
| Cadmium | Cd | <0.00036 | 0 |
| Tin | Sn | <0.00056 | 0 |
| Antimony | Sb | 0.0018 | 0.00024 |
| Barium | Ba | 0.0064 | 0.0015 |
| Tungsten | W | <0.00016 | 0 |
| Mercury | Hg | <0.00006 | 0 |
| Lead | Pb | 0.00005 | 0.00004 |

## Ion Chromatography

| Component name | Retention time | Amount (ppm) |
|---|---|---|
| Fluoride | 2.42 | 0.8 |
| Chloride | 2.92 | 15.1 |
| Bromide | 4.2 | 0.9 |
| Sulphate | 5.92 | 0.07 |

## Inductively Coupled Plasma Atomic Emission Spectrometry

| Element | Symbol | Concentration Mean (ppm) |
|---|---|---|
| Aluminium | Al | 0.001 |
| Arsenic | As | 0.067 |
| Boron | B | 0.059 |
| Calcium | Ca | 2.189 |
| Cadmium | Cd | 0.002 |
| Cobalt | Co | <lod |
| Chromium | Cr | 0.009 |
| Copper | Cu | 0.005 |
| Iron | Fe | <lod |
| Germanium | Ge | 0.181 |
| Mercury | Hg | 0.157 |
| Potassium | K | 0.355 |
| Magnesium | Mg | 0.106 |
| Manganese | Mn | 0.002 |
| Sodium | Na | 3.422 |
| Nickel | Ni | 0.049 |
| Phosphorous | P | 0.176 |
| Lead | Pb | 0.041 |

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| | | |
|---|---|---|
| Sulphur | S | 0.118 |
| Antimony | Sb | 0.117 |
| Selenium | Se | 0.059 |
| Silicon | Si | 1.591 |
| Tin | Sn | 0.091 |
| Strontium | Sr | <lod |
| Titanium | Ti | 0.001 |
| Vanadium | V | 0.024 |
| Zinc | Zn | <lod |
| Lithium | Li | 0.007 |
| Beryllium | Be | <lod |

## Biochemical Oxygen Demand

BOD5 results are as follows (all in mg/l)

1:10,000 solution

| Day | BOD |
|---|---|
| 1 | 0 |
| 2 | 3 |
| 3 | 6 |
| 4 | 8 |
| 5 | 9 |

1:1,000 solution

| Day | BOD |
|---|---|
| 1 | 2 |
| 2 | 14 |
| 3 | 25 |
| 4 | 31 |
| 5 | 36 |

## Eco-Toxicology

| Dilution | Mortality (%) |
|---|---|
| 1:10,000 solution | 15 |
| 1:1,000 solution | 42 |

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# 4. Interpretation

## Chemical content

For all the analytes (elements and anions) measured the concentration in PURE-BORE can be considered very low and for the majority of analytes are only just above the limit of detection of the instruments. Sodium (3.42 ppm and 0.75%), calcium (2.19 ppm and 0.62 %) and chloride (15.1 ppm) are present in quantities greater than all the other analytes but can still be considered very low and at these concentrations would not be considered an environmental threat.

## $BOD_5$

The $BOD_5$ of PURE-BORE, when diluted to a concentration of 1:1000, can be considered similar to that of treated sewage and other effluents that are emitted directly into surface waters. The $BOD_5$ of a 1:10000 dilution is below a level that would be considered an environmental threat and is similar to that of many unpolluted surface waters. As a comparison typical $BOD_5$ from various sources has been measured as follows:

| Source | Typical $BOD_5$ (mg/l) |
|---|---|
| Hand basin greywater | 109 (Al-Jayyousi, 2003) |
| Normal domestic wastewater | 100-200 (Garcia, et al. 1995) |
| Treated sewage | 20-60 (DEFRA) |

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### Eco-toxicity

A PURE-BORE concentration of 1:10000 showed only a 15% mortality rate after 48 hours exposure, as 10% mortality is allowable for experimental error, the toxicity at this concentration can be assumed to be negligible. At a 1:1000 concentration 42% of the juvenile *Daphia magna* were immobile after exposure for 48 hours. Therefore, the test suggests a degree of toxicity at this PURE-BORE concentration.

## 5. Conclusions

1. The chemical analysis of PURE-BORE shows that the concentrations of the elemental and anionic analytes measured is very low.
2. The BOD can be considered relatively high. However, this would be expected for an organic based material such as PURE-BORE which is designed to readily biodegrade.
3. The eco-toxicology test suggests a certain degree of toxicity at the 1:1000 concentration, but toxicity decreases to almost zero when diluted 1:10000. Any toxicity that was observed in the test organisms is likely to be due to the oxygen demand of PURE-BORE, as opposed to any chemical toxicity. For a more complete understanding of toxicity a full ECOTOX 02 test would be useful.

## 5. References

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Al-Jayyousi, O R. (2003) Greywater reuse: towards sustainable water management. Desalination. 156. pp. 181 – 192.

Department of Environment Food and Rural Affairs (1999) Economic instruments for water pollution discharges.

Garcia, A. Rivas, H M. Figueroa, J L and Monroe, A L. (1995) Case history: Pharmaceutical wastewater treatment plant upgrade, Smithkline Beecham Pharmaceuticals Company. Desakination, 102. pp. 255-263.

Horan, N J. Gohar, H and Hill, B. (1997) Application of a granular activated carbon-biological fluidised bed for the treatment of landfill leachates containing high concentrations of ammonia. Water Science and technology. 36. pp. 369-375.

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**Appendix 4**

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DRILLING PRODUCTS FOR THE FUTURE

**PRESS RELEASE**

**Horizontal Directional Drilling Project under Milford Haven breaks European Records**

- The longest HDD to have been completed in Europe
- Arguably the World's longest HDD in rock
- Project completes ahead of schedule
- *Pure-Bore®* based drilling fluid system approved for use by the Environment Agency

*28th February 2011.* The recent installation of a 457mm diameter, 3000m long gas pipeline under Milford Haven, South Wales has completed ahead of schedule, with minimal environmental impact.

The trial drill commenced in May 2007 and Clear Solutions worked closely with the drilling contractor, LMR Drilling UK Ltd, to test the viability of the crossing. Clear Solutions environmentally friendly, water-based Pure-Bore® drilling fluids system was approved for use by The Environment Agency and this - together with the expertise of the Clear Solutions drilling fluids engineers - contributed to ensuring the outstanding success of the project.

The rock under the Haven primarily comprises the steeply dipping Devonian Old Red Sandstone Formation. The drill line also passed through the Ritic Fault - a major regional fault plane. The strength and abrasivity of the rock over this crossing length presented a considerable challenge for the HDD, and the downhole tooling and drilling fluids regime had to be chosen carefully to mitigate risk wherever possible. All drilling fluids engineering was performed by Clear Solutions, who ensured constant monitoring of the drillings fluid rheology. Clear Solutions ensured that the large formation cuttings remained in suspension and were transported effectively for the unprecedented distance from cutting face back to surface.

Clear Solutions identified a series of critical drilling fluids properties for the project which were achieved and maintained using the company's own proprietary products. The outcome was a highly inhibitive fluid providing outstanding hole cleaning, borehole stability, effective clay inhibition, lubricity and a slick gauge borehole. The results were outstanding, with construction of the HDD crossing commencing in October 2009 and completion just 7 months later in May 2010. *Ends*

***Notes:***
*Clear Solutions International Limited is an independent drilling fluids specialist, employing a team of geotechnical specialists and drilling fluids engineers across Europe. The company has developed a range of revolutionary water-based drilling fluids, including Pure-Bore®, and continues to lead the field with its products. The company has worked extensively on high-performance drilling and underground construction projects, and prides itself on providing an environmentally friendly world-class service.*

*For further information contact:*
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*www.drilling-products.com / www.pure-bore.com*

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**Appendix 5**

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Cefas

DEPARTMENT OF ENERGY & CLIMATE CHANGE

# Pure-Bore®

**Clear Solutions International Ltd , Unit B3 Wem Industrial Estate, Soulton Road , Wem , Shropshire, SY4 5SD, United Kingdom**

*Registration No:* 24868 *Version No:* 1 *Expiry Date:* 21/03/2015

| Application Process System | Dose Rate | Worst Aquatic Toxicity Test | Number of Aquatic Toxicity Tests | OCNS Group | 100% PLONOR |
|---|---|---|---|---|---|
| CHARM is not applicable to this process system | 3000 ppm | N/A | N/A | E | Yes |

| Application | Surfactant Type | Drilling Mud Density kg/m3 | Sediment Reworker | Biodegradation Value/ % | Time/Days | Protocol | Minimum Log Po/w | Koc | Koc Protocol | Organic C Content |
|---|---|---|---|---|---|---|---|---|---|---|
| CHARM N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |