Technical Overview

**Summary**

The Department has received an application for a Petroleum Licence covering a large area to the west of Upper Lough Erne and south of Lower Lough Erne. This area overlies part of a geological basin, with deeply buried sedimentary rocks that are likely to include organic rich source/reservoir rocks and reservoir sealing rocks. The underlying geology means that there may potential for natural gas to be present. This document provides you with detailed information about the geology, the history of exploration in this area and the Applicant’s proposed work programme.

**Location and Geology**

The area under consideration in this application comprises approximately 650 sq. km. to the west of Upper Lough Erne and south of Lower Lough Erne in County Fermanagh. This area forms part of the geological Lough Allen sedimentary basin in counties Fermanagh, Leitrim and Cavan, which is known to contain rocks of Early Carboniferous age. In the deepest parts of the basin there are successions of Carboniferous and possibly older Devonian sedimentary rocks more than 3.5 kilometres thick. In terms of petroleum geology the Carboniferous strata contain organic-rich shales (potential source rocks and reservoirs), limestones, sandstones (potential reservoir rocks) and mudrocks (potential caprocks or seals).

Unlike in some other parts of Northern Ireland, the Carboniferous shales are known to have been buried for long enough and deep enough for some of the organic matter to have been converted to gas and there may be sufficient gas remaining within the shale for it to be considered as a shale gas reservoir. Chemical and thermal analysis of the shales suggest that the rocks now at the surface are mature for oil and gas and those at depth are mature for wet or dry gas. Significant uplift of the area after deposition and erosion of overlying sediments means that these rocks are no longer generating oil or gas. Much of the gas that

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1 The Lough Allen sedimentary basin is itself part of a larger sedimentary basin complex sometimes termed the Northwest Irish Carboniferous Basin
was originally generated from the shales may have migrated up to the surface and escaped to the atmosphere during periods of uplift and tectonic faulting in the distant geological past.

Figure 1 below shows the Generalised stratigraphy for the Lough Allen Basin in the west of Co. Fermanagh. The units are depicted at their maximum known thickness in that area to form a stratigraphic column. Not all units are present across the area and there is some variability with the lower formations.

**Figure 1  Stratigraphy for the Lough Allen Basin**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Reservoir</th>
<th>Source rock</th>
<th>Seal</th>
<th>Dominant rock types</th>
<th>Thickness (m)</th>
<th>Stratigraphic unit</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 km</td>
<td></td>
<td></td>
<td></td>
<td>Sandstones</td>
<td>0-300</td>
<td>Glenade Sandstone Formation</td>
<td></td>
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<tr>
<td>2 km</td>
<td></td>
<td></td>
<td></td>
<td>Organic-rich shales, thin limestones and evaporites</td>
<td>0-240</td>
<td>Meenmore Formation</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Carbonate mudmounds and cherty limestone</td>
<td>90-280</td>
<td>Dartry Limestone Formation</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Muddy limestone and calcaceous mudstone</td>
<td>70-170</td>
<td>Glencar Limestone Formation</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Calcarous mudrocks and thin limestones</td>
<td>240-365</td>
<td>Benbulben Shale Formation</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Sandstones, silty mudstone and minor limestone</td>
<td>150-216</td>
<td>Mullaghmore Sandstone Formation</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Calcarous mudrocks and thin limestones</td>
<td>555</td>
<td>Bundoran Shale Formation (Dowra Member toward base)</td>
<td>Carboniferous</td>
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<td></td>
<td></td>
<td>Shelly limestones /argillaceous limestones and mudstones</td>
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<td>Ballyshannon Limestone Formation/Kilbyran Limestone Formation</td>
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<td>Sandstone, sandy limestone and mudstone</td>
<td>0-112</td>
<td>Twigrspark Sandstone Formation</td>
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<td></td>
<td></td>
<td></td>
<td>Sandstones and mudstones</td>
<td>328-386</td>
<td>Boyle Sandstone Formation</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Sandstone and conglomerate</td>
<td>&gt;177</td>
<td>Kilcoo Sandstone Formation</td>
<td></td>
</tr>
</tbody>
</table>

**Key**

- Mudrocks (claystone/siltstone)
- Limestone
- Sandstone
- Pebbley sandstone/conglomerate and breccia
- Metamorphic rocks

**Basement metamorphics**

**Precambrian**
Figure 2 below shows the distribution of the Bundoran Shale at the surface (dark green) and beneath the surface (light green). In general the depth to the top of the shale increases towards the west. The lower image is a seismic reflection line (marked on the map as a thick dashed line from A to B). It shows how a number of large faults (thick black lines) have brought the Bundoran Shale Formation (shaded green) up to the surface at the margins of the basin.

**Figure 2  Distribution of the Bundoran Shale**
Previous exploration in the area

The area has previously formed part of Petroleum Licences in the 1960’s, 1980’s and 2000’s (Licences PL1/65, PL4/81, PL1/00, PL2/00 and PL3/00). The first exploration wells in the area, Big Dog No. 1 and Owengarr No. 1, drilled in 1965, proved that gas was present, but were plugged and abandoned. In 1981 two sandstone intervals in the Dowra No. 1 well, drilled in 1963 in County Cavan, were hydraulically fractured resulting in a tenfold increase in flow rates. On their own these results did not indicate a commercially viable gas discovery but they did encourage further exploration. A regional seismic survey was shot across the basin in 1981 and two further wells were drilled in 1984-85 (Kilcoo Cross and Slisgarrow). All these wells (Figure 3) had shows of gas from various horizons, including shales and limestones as well as the target sandstone intervals.

Figure 3  Map of Hydrocarbon Exploration Wells in the Lough Allen Basin

Figure 3 above shows the location of hydrocarbon exploration wells in the Lough Allen Basin, in Northern Ireland and the Republic of Ireland. The depth in metres from the ground surface to the top of the Bundoran Shale Formation is shown above the well. All wells recorded gas shows apart from Glennoo, drilled to the east in South Co. Tyrone.
The primary target Mullaghmore Sandstone Formation reservoirs displayed poor reservoir quality and the gas that was present either did not flow to the surface or was not present in economic volumes. In 2000 Evergreen Resources, a US company with experience of producing gas from similar ‘tight gas’ sandstones, was granted licences in the Lough Allen basin and drilled four new wells in Fermanagh. The company hydraulically fractured selected intervals in the Mullaghmore Sandstone Formation and ran extended well tests but gas flowed at non-commercial rates. Modelling suggested that significantly better flow rates could be achieved by hydraulically fracturing the sandstone in horizontal wells (all wells drilled to date have been vertical), but Evergreen Resources decided to relinquish the licences without further drilling.

Tamboran Resources (UK) Ltd were awarded a licence (PL2/10) in 2011, with the aim of exploring for shale gas in the Bundoran Shale (Figure 2). The company carried out desk studies and analyses of shale samples but the licence terminated when the company failed to complete Part I of the Work Programme within the required timescale. The main uncompleted component of the Work Programme was the drilling of a stratigraphic borehole to collect fresh core samples of the Bundoran shale in order to ascertain the organic carbon and gas content in place at depth. This information would provide a reasonable indication as to whether or not it would be worth proceeding to drill and test an exploration well, from a technical viewpoint. The depth of the Bundoran Shale Formation can fairly confidently be predicted across most of the area, but other aspects such as the detailed tectonic setting and the reservoir characteristics of the shale are less well understood, and these would need to be evaluated in any future exploration programme.

**Proposed Work Programme**

The applicant has applied for an area with the express interest of evaluating the shale gas prospectivity of the Bundoran Shale Formation. The Dowra Sandstone Member, a low permeability sandstone near the base of the Bundoran which flowed significant volumes of gas in the Dowra No. 1 well, is regarded as a secondary target. The exploration strategy involves a stepwise approach with a stratigraphic borehole to recover core from the Bundoran Shale Formation being central to Part I of the Work Programme.

One of the main exploration challenges is to discover whether the Bundoran Shale still contains enough gas for it to produce gas at commercially viable rates. The Bundoran Shale was not the primary target in previous wells and the cuttings samples recovered do not provide enough information about this. Analyses of these samples and other rock samples collected from surface outcrops indicate Total Organic Carbon (TOC) generally up to about 1% whereas 2% TOC has often been used as an economic cut-off in the USA. However, cuttings and outcrop samples analyses can underestimate the TOC and gas-in-place within the shales so that it is important to obtain fresh rock core from the shales at depth. Data about rock core from a single stratigraphic borehole cannot be used to generalise about the Bundoran Shale throughout the basin but the information acquired would be important in deciding whether or not there was any realistic prospect of producing commercial gas flows in the basin.

Although the production of oil and gas from shales has increased markedly in the last 15 years or so (shale gas was 0.5% of global production in 2000 and 13% in 2015), the vast majority of this production has been in the USA and Canada. In North America there is a long history of oil and gas production, a large pool of equipment and experienced personnel
and a generally supportive regulatory regime. In Europe there has been relatively little exploration and production, industry capacity and experience is limited, regulatory restrictions are greater and there is more active opposition to the use of high volume hydraulic fracturing (“fracking”). In addition, many of the areas in Europe with shale gas resources are more densely populated than those in North America and the geological settings are different. Consequently, the initial stages of Tamboran’s Work Programme would include a detailed structural interpretation of the area and extensive public engagement. Part I of the Work Programme would not include any fracking. If the results from Part I were favourable, and DfE were satisfied with their performance, the company would decide whether they wished to proceed to Part II which would include the drilling, fracking and testing of at least one exploration well. These operations would be conditional on the company obtaining a number of planning, environmental, technical and health and safety consents, which would involve careful assessment of detailed proposals. In the context of planning permission, it should be noted that Paragraph 6.158 of the 2014 Strategic Planning Policy Statement for Northern Ireland (SPPS) states that “in relation to unconventional hydrocarbon extraction there should be a presumption against their exploitation until there is sufficient and robust evidence on all environmental impacts.” The SPPS sets out the regional planning policies for Northern Ireland which must be taken into account in the preparation of Local Development Plans, and are also material to all decisions on individual planning applications and appeals.

Summary of proposed Work Programme

Years 1 – 3 (Part I)
- Initiate public engagement programme.
- Re-analysis of existing exploration data, including structural interpretation.
- Identification of potential drilling sites for a stratigraphic borehole; obtain suitable site, design drilling programme for stratigraphic borehole, carry out baseline environmental monitoring.
- Prepare and submit application for permission to drill stratigraphic borehole.
- Subject to obtaining necessary approvals, prepare site and drill stratigraphic borehole, cut and analyse Bundoran Shale core for gas content, mechanical and chemical properties, run downhole geophysical logs.
- Subject to positive results from the stratigraphic borehole, the company will begin process of selection of exploration well site, design of well operations and environmental baseline monitoring.

Drill or drop decision before end of Year 3 – the company informs DfE of its intention to proceed to part II of the Work Programme or it ‘drops’ – relinquishes – the licence without drilling an exploration well.

Years 4 – 5 (Part II)
- Carry out an Environmental Risk Assessment for proposed shale gas operations as a first stage risk assessment and starting point for engagement with regulators and local communities.
- Complete and interpret a 3D seismic survey over areas of interest.
- Complete plan & design of exploration well, including fracking and testing programme, and all associated monitoring programmes.
- Submit applications for all permits associated with proposed well operations (including planning, technical, environmental, Health & Safety)
- Subject to obtaining all necessary permits, drill exploration well, carry out hydraulically fracturing and testing.
- Analyse results.
- Plug and abandon well, restore wellsite or, if successful, complete well for possible future production.

Depending on the results from the exploration well, the company would inform DfE of their intention to proceed to the Second Term of the Licence, to appraise the drilling results, or relinquish the Licence. In any event the company would relinquish at least 50% of the Licence area.

This is outlined in the following legislation-