

DERBYSHIRE AND DERBY MINERALS LOCAL PLAN

UNCONVENTIONAL GAS - SHALE GAS SUPPORTING PAPER

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1 Introduction and Background

1.1 This is one of a series of papers providing background, supporting information to accompany the preparation of the new Minerals Local Plan. The new Plan will include strategies and policies concerning the winning and working of hydrocarbon based energy minerals. This paper provides information about gas obtained from shale deposits (an unconventional source) whilst corresponding papers focus on oil and gas from conventional sources and gas obtained from within coal measures. The production of separate papers reflects both the issues that have been raised and response to comments received in previous consultation exercises and the views expressed to the County and City Councils in response to publicity for individual planning applications. Some of the issues and legislative provisions are common to all three forms of hydrocarbon developments and therefore there is some level of duplication in the papers but this is necessary to ensure that each one provides a comprehensive review of the issues for those who read them individually.

1.2 Conventional and Unconventional Hydrocarbons

Hydrocarbon is a compound of hydrogen and carbon. Hydrocarbons are of great importance as they include minerals such as oil and gas which provide a significant proportion of our energy supplies. The geological conditions where these resources are found, and the methods used to extract them has resulted in two categories of energy based hydrocarbons; conventional and unconventional hydrocarbons. Conventional hydrocarbons are oil and gas where the reservoir is sandstone and limestone. Unconventional hydrocarbons refer to oil and gas which comes from sources such as shale or coal seams which act as the reservoir. This paper focuses on shale gas and the issues associated with its extraction.

1.3 What is Shale Gas?

Shale is a common type of fine grained sedimentary rock formed from deposits of mud, silt, clay and organic matter. Through the application of heat and pressure over geological time, gas (predominantly methane) is produced from this organic matter. Methane is a 'natural gas' and is used to generate electricity and for domestic heating

and cooking. Gas contained within shale is often referred to as ‘unconventional gas’ by contrast to ‘conventional gas’ obtained from sandstones or limestone. Conventional gas is found in reservoirs where it has migrated up from the source rock. In contrast shale gas has to be obtained directly from the source rock.

1.4 How is the Gas Extracted?

The techniques available to obtain the gas from conventional or unconventional sources are essentially the same but they have to be applied in a different way for shale gas as shales have a relatively low permeability and gas can only flow from them at very low rates. The shale has to be broken or opened to enable the gas to flow out and be captured.

All the techniques currently available involve drilling down to the shale beds. The drill shafts can consist of a single and direct vertical path to the shale bed. An alternative is Horizontal Drilling, in which the well trajectory is turned horizontally, sometimes running for thousands of feet along a layer of rock. A single horizontal well can access a much larger volume than a vertical well, reducing the number of wells that need to be drilled, and thereby the overall cost of production.

Whereas conventional gas is found in reservoirs, shale gas is trapped in small gaps in the host shale. The shale therefore has to be broken down to allow access to these pockets of gas. Hydraulic fracturing or “fracking” is a relatively new technique for extracting gas from shale. It is a technique that uses fluid, usually water, pumped at high pressure into the rock to create narrow fractures which form pathways allowing the gas to flow into the well bore and up to the surface. The water normally contains small quantities of other substances to improve the efficiency of the operation. Sand is often pumped into the fractures to keep them open and allow the gas to flow out. The fluids pumped into the shale are referred to as proppants (props to keep it open) and can include small quantities of chemicals. The fractures extend a few hundred metres into the rock and the newly created fractures and other fluids in addition can be pumped into the well to maintain the pressure so that fracture development can continue and the proppant can be carried deeper into the formation.

More information about hydraulic fracturing can be obtained from the series of publications issued by the Department of Energy and Climate Change (DECC), including Developing Onshore Shale Gas and Oil – Facts about ‘Fracking’, December 2013.

A well may be too long to maintain sufficient pressure to stimulate fractures across its entire length. Plugs may be inserted to divide the well into smaller sections (‘stages’). Stages are fractured sequentially, beginning with the stage furthest away and moving towards the start of the well. After fracturing, the plugs are drilled through and the well is depressurised. This creates a pressure gradient so that gas flows out of the shale into the well. Fracturing fluid flows back to the surface (‘flowback water’) but it now also contains saline water with dissolved minerals from the shale formation (‘formation water’). Fracturing fluid and formation water returns to the surface over the lifetime of the well as it continues to produce shale gas (‘produced water’). Although definitions vary, flowback water and produced water collectively constitute mining waste and require an environmental permit for disposal to a waste water treatment works. DECC publication About Shale Gas and Hydraulic Fracturing (Fracking), July 2013, indicates that the treatment options which are available include:

- on-site treatment with re-use of water and disposal of remaining liquids and solids to a suitable licensed waste treatment and disposal facility or effluent discharge
- removal off site to a suitable licensed waste treatment and disposal facility;
- disposal to foul sewer with the permission of the relevant waste water utility company.

2 Regulatory System

2.1 Key Regulators

Anyone seeking to carry out operations for the extraction of hydrocarbons, including gas from shale, has to obtain approval from the appropriate regulatory bodies. Guidance on the regulatory process is available from DECC in the Regulatory

Roadmap: Onshore Oil and Gas Exploration in the UK – Regulation and Best Practice, December 2013. The key regulators for all hydrocarbon extraction operations are:

- **Department of Energy and Climate Change** – issue Petroleum Licences, give consent to drill under the Licence once other permissions and approvals are in place, and have responsibility for assessing risk of and monitoring seismic activity, as well as granting consent to flaring or venting. Further details of the licensing regime are provided below.
- **Oil and Gas Authority** - as of 1 April 2015 certain functions passed from the Department of Energy and Climate Change to the Oil and Gas Authority (OGA) a newly created Executive Agency of DECC. It works with Government and industry to make sure that the UK gets maximum economic benefit from its oil and gas reserves. It is now responsible for regulating offshore and onshore oil and gas operations relating to licensing, exploration and production, fields and wells, infrastructure and carbon capture and storage licensing.
- **Minerals Planning Authorities** – grant planning permission for the location of any wells and wellpads, and impose conditions to ensure that the impact on the use of the land is acceptable
- **Environment Agency** – protect water resources (including groundwater aquifers), ensure appropriate treatment and disposal of mining waste, emissions to air, and suitable treatment and manage any naturally occurring radioactive materials, and
- **Health and Safety Executive** - regulates the safety aspects of all phases of extraction, in particular responsibility for ensuring the appropriate design and construction of a well casing for any borehole.

Other bodies which may be involved in the consenting of the process include:

- **the Coal Authority**, whose permission will be required should drilling go through a coal seam
- **Natural England**, who may need to issue European Protected Species Licences in certain circumstances

- **the British Geological Survey**, who need to be notified by licensees of their intention to undertake drilling and, upon completion of drilling, must also receive drilling records and cores, and
- **Hazardous Substances Authorities**, who may need to provide hazardous substances consents.

There may also be additional consents and orders, such as stopping up rights of way or temporary road orders, which must be obtained.

2.2 **Obtaining Planning Permission and Other Approvals**

Apart from a few exceptions, all works associated with the extraction of hydrocarbons require planning permission. The process of obtaining planning permission to drill a well is the same whether the well is targeted at conventional gas resources or unconventional gas (e.g. shale gas). The process involves three separate stages; exploration, appraisal and extraction, and all stages require separate planning permissions.

The exploratory phase seeks to acquire geological data to establish whether hydrocarbons are present. The appraisal stage takes place when the existence of gas (or oil) has been confirmed, but where the operator needs further information about the extent of the deposit or its characteristics to establish whether it can be economically extracted. The production stage normally involves the drilling of a number of wells and may also involve the installation of ancillary equipment such as pipelines, processing facilities and storage tanks.

In order to undertake any works related to gas extraction an operator has to have a licence which is issued by the DECC (now OGA or any successor). Licences are issued in competitive offerings (Licence Rounds) which grant exclusivity to operators in the licence area. The licences however do not give consent for drilling or any other operations.

The DECC Regulatory Roadmap contains the following checklist which identifies that before commencing drilling operations for all onshore oil and gas development the operator must have:

- obtained a petroleum exploration and development licence (PEDL) from DECC or petroleum licence (PL) from the Department of Enterprise, Trade and Investment (DETI)
- secured a lease from the landowner
- submitted relevant Petroleum Operations Notices (PON) to DECC/DETI
- satisfied DECC/DETI that effective operational and environmental management systems are in place
- secured planning permission
- discharged any relevant conditions placed on the planning permission
- obtained a permit from the Coal Authority if the well will encroach on coal seams
- informed the British Geological Survey of the intention to drill
- completed the necessary consultation processed with all the statutory/relevant consultees
- obtained the necessary permits from the Environment Agency
- notified HSE of the intention to drill (minimum 21 days' notice)
- provided HSE with details of the proposed well design that have been examined by an independent and competent well examiner (minimum 21 days' notice)
- agreed data-reporting methods with DECC/DETI
- agreed a method for monitoring induced seismicity and fracture growth height with DECC/DETI, where hydraulic fracturing is planned
- received approval for an outline fracturing programme from DECC/DETI, where hydraulic fracturing is planned.

This checklist predates the introduction of the Oil and Gas Authority and does not reflect any changes that may follow. Further details of this process are summarised below.

The submission of an application to the mineral planning authority triggers the need to determine if an Environmental Impact Assessment (EIA) is required. An EIA will be required if the scale of the proposed development exceeds certain thresholds, or if, depending on the nature, scale and location, the development may have significant environmental impacts. If an EIA is required, it must be completed by the applicant and submitted to the mineral planning authority before the authority decides on the application. Operators are encouraged to engage in pre-application discussions with the mineral planning authority where the need for an EIA and the matters to be addressed in it can be determined before an application is prepared and submitted. Government policy also encourages would-be applicants to undertake community engagement. Applicants are advised to inform local communities about their proposals and, where appropriate, amend those proposals in response to the feedback they receive.

Following a consultation in September 2013 and Government response in January 2014, changes were made to the system of how landowners and tenants should be notified by applicants of applications for onshore oil and gas development. The requirement to serve notice on individual owners and tenants of land on the above ground area where works are required was retained, but the requirement for owners of land beyond this area i.e. the owners of land where solely underground operations may take place, was removed. This was implemented by the Town and Country Planning (Development Management Procedure and Section 62A Applications) (England) (Amendment No.2) which came into force from 13 January 2014.

Once the LPA has granted planning permission to drill, and at least 21 days before drilling is planned, the Health and Safety Executive (HSE) must be notified of the well design and operation plans to ensure that major accident hazard risks to people from well and well related activities are properly controlled, and are subject to the same stringent regulation as any industrial activity. HSE regulations also require verification of the well design by an independent third party. Notification of an intention to drill has to be served to the environmental regulator under S199 of the Water Resources Act, 1991.

DECC (now OGA or any successor) will then check that the other regulators have no objections before consenting drilling operations. If hydraulic fracturing is intended, DECC (OGA) will require that a fracturing plan to address the risk of induced seismicity is submitted, and will review this plan before these operations are permitted.

If the operator wishes to drill an appraisal well or propose to start production operations, they start again with the process described above; the landowner's consent, permissions and planning consent, (which may require EIA and approval from the Environment Agency), the HSE, and finally a decision from DECC (OGA).

The Planning and other regulatory regimes are separate but complementary. The planning system controls the development and the use of the land in the public interest and, this includes ensuring that new development is appropriate for the location taking account of the effects, including cumulative effects, of pollution on health, the natural environment, general amenity and the potential sensitivity of the area or proposed development to adverse effects from pollution (see paragraphs 120 and 122 of the NPPF). The focus is on whether the development is an acceptable use of the land, and the impacts of those uses, rather than the control of the processes involved and health and safety. The information above briefly outlines the regulatory responsibilities for these issues.

All planning applications have to be assessed on the individual merits of the case, taking account of national and local policy. This applies to all proposals for oil and gas extraction from both conventional and unconventional sources using traditional or new techniques. In the early part of 2013 media coverage of proposals for hydraulic fracturing for shale gas led to concerns that such developments would be dealt with by the fast-track route for nationally significant business and commercial development proposed in the Growth and Infrastructure Bill by submitting applications to the Planning Inspectorate rather than to local councils. However, on 19 July 2013 in a Ministerial Statement, Baroness Hanham confirmed that "... responsibility for the determination of planning applications for onshore oil and gas, including for the exploration of shale gas, will be with the local authority. Decisions

will therefore continue to be taken in accordance with local plans and the National Planning Policy Framework.”

The situation changed following the publication on 13 August 2015 of a joint statement from the Department of Energy and Climate Change and the Department for Communities and Local Government in which the new measures include:

- The Communities Secretary actively considering calling in on a case by case basis shale planning applications and considering recovering appeals
- Identifying councils that repeatedly fail to determine oil and gas applications within the 16 week statutory timeframe requirement (unless applicants agree to a longer period). Underperforming councils gas and oil planning applications could be determined by the Communities Secretary
- Adding shale applications as a specific criterion for recovery of appeals, to ensure no application can ‘fall through the cracks’
- Ensuring planning call ins and appeals involving shale applications are prioritised by the Planning Inspectorate
- Taking forward work on revising permitted development rights for drilling boreholes for groundwater monitoring.

Coverage of recent hydrocarbon operations in the press and media, especially those involving hydraulic fracturing, have focused on a number of important issues, including seismic risks and the chemical content of hydraulic fracturing fluid. The National Planning Practice guidance states that whilst these issues may be put to the mineral planning authority, the responsibility for assessment rests with other regulators. Mineral planning authorities have to assume that these other regulators will carry out their duties and responsibilities. They do not have to undertake their own assessments and should rely on the assessments of these regulators. Prior to granting planning permission, however, the mineral planning authority will need to be satisfied that these issues can and will be adequately addressed by taking advice from the appropriate regulator.

3. Licensing of Oil and Gas Exploration and Development

- 3.1 The Petroleum Act 1998 vests all rights and ownership of the petroleum resources (oil and gas) of Great Britain and the United Kingdom territorial waters in the Crown. The Secretary of State for Trade and Industry (DTI) (or successor) grants licences to persons that confer exclusive rights to 'search and bore for and get' these resources. The Department for Energy and Climate Change (successor to DTI) has a regular timetable of licencing rounds, with generally one onshore round per year. Licences are awarded to those bids promising to optimise the exploitation of the UK's petroleum resources. This function has now passed to the OGA.
- 3.2 The main objectives of the licencing regime are to secure the comprehensive exploration and appraisal of UK oil and gas resources and the economic development of discovered reserves. The rights granted by landward licences do not include any rights of access, and the onus is upon the licensee to obtain all the relevant authorisations and planning permissions from the respective authorities and landowners.
- 3.3 As a result of the long history of legislation, several types of onshore licence existed. To simplify things, the DTI in 1996 commenced the issue of Petroleum Exploration and Development (PEDL) Licences at the 8th Licensing Round. These carry a three-term lifetime: a six-year Initial Term allows completion of an agreed Work Programme, which is a pre-condition of entry into the five-year Second Term. Successful completion and approval of a development plan is a pre-condition of entry to the Third Term for production, which is granted for a period of 20 years, although the Secretary of State has the discretion to extend this period if production is continuing.
- 3.4 Following the announcement of a new round of licensing offers, applications are made for a PEDL over unlicensed areas (blocks) which correspond to the 10 km by 10 km Ordnance Survey grid. Many licences cover more than one block. Licensees are entitled to surrender a Licence, or part of the acreage covered by it, at any time after the Initial Term and the Work Programme have been completed, with a minimum

relinquishment required at the end of the Initial Term. Details of the existing licence areas and those to be conferred under the 14th Onshore Oil and gas Licensing Round can be obtained via the following link: <https://www.gov.uk/government/news/new-onshore-oil-and-gas-blocks-to-be-offered>.

4 Policy Considerations

4.1 Government policy and guidance relating to the extraction of all hydrocarbons, including shale gas, is developing rapidly in response to the discovery of new reserves and the emergence of new techniques for working those reserves. Accordingly the collective policy statements are to be found in a number of publications.

4.2 National Planning Policy Framework, 2012

National guidance for the extraction of minerals, including hydrocarbons, is set out in the National Planning Policy Framework. In general terms, the NPPF states that, "Minerals are essential to support sustainable economic growth and our quality of life. It is therefore important that there is a sufficient supply of material to provide the infrastructure, buildings, energy and goods that the country needs. However, since minerals are a finite natural resource and can only be worked where they are found, it is important to make best use of them to secure their long-term conservation."

Specific but limited guidance on hydrocarbons is set out in Paragraph 147 of the NPPF which states that, "Minerals Planning Authorities should also...when planning for on-shore oil and gas development, including unconventional hydrocarbons, clearly distinguish between the three phases of development (exploration, appraisal and production) and address constraints on production and processing within areas that are licensed for oil and gas exploration or production..."

4.3 National Energy Policy

There have been several important stages in the evolution of current national energy policy. The Department of Trade and Industry paper, Meeting the Energy Challenge,

2007 states that England, Wales and Scotland's substantial remaining coal reserves have the potential not only to help meet our national demand for coal and to reduce our dependence on imported primary fuels, but also to contribute to the economic vitality and skills base of the regions where they are found.

The draft National Policy Statement for Energy, published in 2009, builds on the 2007 Energy White Paper. Together they form an evolving international and domestic energy strategy in response to the changing circumstances in global energy markets. They set out to address the long-term energy challenges of security of supply, whilst acknowledging the implications of climate change. Whilst recent emphasis has been on the development of renewable energy supplies the Government recognises the important and continuing role that indigenous sources of coal, oil and gas will play in meeting national energy requirements.

This policy is set against the background of recent changes in the sources of our energy requirements. By 2004 the United Kingdom became a net importer of natural gas and a net importer of oil in 2010. By 2020, it was then estimated that the UK is likely to be importing about three-quarters of its energy supplies.

On 27 June 2013 the Government announced its long-term infrastructure investment plans which included a package of reforms to enable shale gas exploitation. The Government recognised that the simultaneous announcement of the extent of potential reserves required further appraisal but consider that shale gas has the potential to contribute significantly to the UKs' energy security, inward investment and growth.

The announcement did not make any specific statements concerning the planning system but it did expand on the provision of community benefits from shale gas extraction. It stated that the companies involved in this industry should fully engage with the local communities as early as possible and that they would provide direct benefits to the areas where shale gas extraction took place. The benefits would

include £100,000 for each community situated near each exploratory well and 1% of the revenue from every production site.

The statement indicated that a key role for gas is consistent with the need to decarbonise our economy. It is regarded as the cleanest fossil fuel, and much of the new gas capacity needed would be replacing the ageing coal capacity. Gas is also seen as important for balancing the increasing levels of intermittent and inflexible low-carbon energy on the system.

4.4 Energy Act 2013

The Energy Act received final assent on 18 December 2013. The Act has several objectives and in relation to hydrocarbons it seeks to make provision for the setting of a decarbonisation target range and duties in relation to it; or in connection with reforms to the electricity market for purposes of encouraging low carbon electricity generation, or ensuring security of supply. It is also about the designation of a strategy and policy statement concerning domestic supplies of gas and electricity. It does not actually proscribe a new strategy or policy at this stage but instead sets the procedural requirements for doing so. It is likely however that future policy and strategy will reflect the overall objective of the Act to reduce our carbon footprint and in turn this will affect the future demand for minerals including fossil fuels.

4.5 National Planning Practice Guidance, March 2014

The National Planning Practice Guidance was published in March 2014 and contains revised and updated planning practice guidance on a wide range of planning issues. It complements and expands on the policies in the National Planning Policy Framework and replaces a suite of previous guidance, including Planning Practice Guidance for Onshore Oil and Gas, DCLG, July 2013, although it broadly reiterates the advice in that publication relating to the extraction of energy based hydrocarbons.

The guidance provides definitions of conventional and unconventional hydrocarbons. It states that as an emerging form of energy supply there is a pressing need to establish, through exploratory drilling, whether or not there are sufficient recoverable

quantities of unconventional hydrocarbons such as shale gas and coalbed methane present to facilitate economically viable full scale production.

In terms of new guidance it encourages mineral planning authorities to make appropriate provision for hydrocarbons in local mineral plans, based on emerging information, to allow them to highlight areas where proposals for extraction may come forward, as well as managing potentially conflicting objectives for the use of land. It states that mineral planning authorities should identify Petroleum Licence Areas on the proposals maps of local mineral plans and include criteria based policies for each phase; that is exploration, appraisal and production, setting clear guidance for the location and assessment of hydrocarbon extraction within those areas. Existing hydrocarbon extraction sites should be identified in local plans, through the local plan site allocation process, where appropriate, and mineral planning authorities may include new locations should the oil and gas industry wish to promote specific sites. In contrast to the practice established for other minerals resources, the guidance does not advocate the need for the creation of formal safeguarding areas for hydrocarbons due to the depth of those reserves, the ability to use drilling equipment and the small surface area required for the installations.

The guidance provides a summary of the role of mineral planning authorities in obtaining planning permission and the complementary roles of other regulators. Mineral planning authorities are advised to assess applications for each phase on their respective merits and applications for the exploratory stage should not involve the consideration of the potential impacts of extraction. Mineral planning authorities should not consider demand or alternatives to oil and gas when determining applications. It also reiterates the stance of the NPPF where great weight should be given to the benefits of extraction, including benefits to the economy. The guidance advises mineral operators to look to agree a programme of work with the mineral planning authority, which takes account, as far as possible, of the potential impacts and mineral planning authorities are advised to use appropriate conditions to mitigate those potential impacts for which they have responsibility. Operators and mineral planning authorities are also encouraged to seek appropriate restoration

schemes for sites once mineral extraction is completed. The guidance includes a set of model conditions for mineral planning authorities to consider using, where appropriate, on planning permissions for all forms of hydrocarbon extraction developments.

5 Potential Environmental and Other Impacts

5.1 The section above on Regulatory Controls identifies the issues that a mineral planning authority may have to take into account when determining planning applications for shale gas developments. The issues are of relevance to the mineral planning authority because they relate to potential adverse economic, social and environmental impacts and the assessments undertaken on these issues help determine whether or not a proposed development is acceptable.

5.2 Some of these potential impacts are ones which would be common to most other minerals developments, including other forms of hydrocarbon developments. For example, issues such as the levels of noise and dust that would be generated, the impact on the landscape, the volume of traffic and how these impacts are to be controlled.

5.3 In addition there are other potential impacts that will influence the decisions of other regulators and which fall outside the sphere of the planning system. There are however some issues and impacts which are particularly relevant to hydraulic fracturing. These are addressed below using information and opinion obtained from the DECC publications.

5.4 Water Use

Large quantities of water are required during the hydraulic fracturing process. It is estimated that a typical well could use between 10,000 to 30,000 cubic metres of clean water (10,000 to 30,000 tonnes) which will need to be obtained from a local source. A DECC publication states that this is not exceptional compared with other industrial activities, citing as an example an estimate that the amount needed to

operate a fracked well for a decade may be equivalent to the amount needed to water a golf course for a month, or to run a 1,000 MW coal-fired power plant for 12 hours.

There are concerns that this usage could result in the depletion of water within local eco-systems and damage to their integrity and function. All proposals for the abstraction of surface or ground waters are regulated by the Environment Agency who should take account of such potential impacts before issuing a permit. An added concern is the impact on drinking water supplies, especially in periods of drought. This will also be addressed by the Environment Agency with reference to their Water Resources Strategy. Water companies must produce, and then update every 5 years, a long-term plan with contingency reserves in case of a drought. Water companies will assess the amount of water available before providing it to operators.

5.5 Impacts on Ground Water

One of the major potential impacts is the risk of contamination of ground water. The process involves the use of fluids containing potential pollutants which are injected into the ground, where they may enter into the ground water system. The presence of water containing other fluids could also mobilise natural substances in the ground that could then cause pollution. The assessment of these risks is a matter for the Environment Agency under the Environmental Permitting Regulations 2010 (EPR). Where approved, the permit would specify any limits on the activity, any requirements for monitoring, the chemicals which may be used and any limits on permissible concentrations. If the activity poses an unacceptable risk the Environment Agency would not issue a permit. If the Environment Agency decides that the activity could not affect ground water, a permit would not be necessary. In the event that a risk or impact becomes apparent, the Environment Agency could issue a notice requiring the operator to obtain a permit, or in extreme situations, issue a notice prohibiting the operation.

One of the specific concerns that have been raised is the risk of fractures caused by hydraulic fracturing for shale gas extending into aquifers and causing contamination

of ground water. The Government commissioned a review of the scientific and engineering evidence on shale gas extraction which was undertaken by the Royal Academy of Engineering and the Royal Society. This review concluded that “the health, safety and environmental risks associated with hydraulic fracturing (often termed fracking) as a means to extract shale gas can be managed effectively in the UK as long as operational best practices are implemented and enforced through regulation.”

The Royal Society concluded that as the process of hydraulic fracturing takes place at depths of many hundreds of metres or several kilometres, geological mechanisms will constrain the distances that fractures may propagate vertically. The thickness and properties of rock surrounding the fractures limits the volume of rock that is affected by hydraulic fracturing. Evidence was taken from USA operations which indicated that the laminated nature of rocks in the subsurface contain and restrict fracture height growth by what are termed ‘composite layering effects’.

Even if communication with overlying aquifers were possible, suitable pressure conditions would still be necessary for contaminants to flow through fractures. More likely causes of possible environmental contamination include faulty wells, and leaks and spills associated with surface operations. Neither cause is unique to shale gas. Both are common to all oil and gas wells and extractive activities.

Concerns have been raised about the chemicals used in hydraulic fracturing and the potential to pollute the water environment. A large number of chemicals have been used in hydraulic fracturing operations in the USA. In this country the ones which would be allowed to be used would be determined by the Environment Agency on a case by case basis in order to protect the integrity of the water resource. The chemicals used by Cuadrilla, the only company so far to have carried out hydraulic fracturing for shale gas are listed as:

- 99.75% of the fluid is made up of water and sand

- 0.075% polycarylamide friction reducers commonly used in cosmetics and facial creams
- 0.125% hydrochloric acid frequently used in swimming pools and drinking water wells
- 0.005% biocide used on rare occasions when the water provided from a local supplier needs to be purified further.

5.6 Seismic Activity

One of the main concerns is the potential for fracking to result in seismic activity which could result in damage to property and land. Two small earthquakes were recorded of magnitude 1.5 ML (27 May 2011) and magnitude 2.3 ML (1 April 2011) in the Blackpool area near to the shale gas drilling site operated by Cuadrilla Resources (where ML is the local magnitude on the Richter scale of measurement). Shale gas hydraulic fracturing in the wellbore was conducted shortly before both earthquakes occurred. The British Geological Survey concluded that the similarity of the recorded waveforms to those from the magnitude 2.3 event on 1 April suggests that the two events share a similar location and mechanism. Also, that the timing of the two events in conjunction with the fluid injection at the Preese Hall drill site suggests that they may be related to this. A DECC publication states that earthquakes of the magnitude recorded above are not normally felt at the surface

Seismic activity associated with mineral operations is not uncommon in the UK. There are many recorded incidences of seismicity induced by coal mining activities or the settlement of abandoned mines. British Geological Survey records indicate that coal mining-related seismicity is generally of smaller magnitude than natural seismicity and no larger than 4 ML. Seismicity induced by hydraulic fracturing is likely to be of even smaller magnitude. Government publications indicate that there is an emerging consensus that the magnitude of seismicity induced by hydraulic fracturing would be no greater than 3 ML (felt by few people and resulting in negligible, if any, surface impacts).

The risk of seismic activity is the responsibility of the Department of Energy and Climate Change through the licence consent regime. It requires an applicant to provide an assessment of the geology of an area to establish geological conditions, risk of seismic activity and mitigation measures to be put in place for all hydraulic fracturing processes. DECC guidance indicates that since the events in Lancashire new controls are being introduced to mitigate seismic risks whereby a precautionary approach will be adopted for the next few wells, and those operations will be subject to particularly close scrutiny to ensure that the controls are being applied correctly and effectively. This will be regulated through the Hydraulic Fracturing Programme (HFP) operated by DECC.

5.7 Methane Release and Leakage

One concern is the potential for gases to escape from both the well and shale gas hydraulic fracturing fluids into the air. Waste gases, including fugitive emissions, are considered an 'extractive waste' under the Mining Waste Directive. All operators must develop a Waste Management Plan as part of the permit application to the Environment Agency. It must characterise the waste, set out details of how the operator will employ a waste hierarchy, including waste minimisation and safe disposal, as well as any monitoring. Venting and flaring of gases are regulated by DECC as part of licence conditions which require that such activities are kept to the minimum that is technically possible. Routine venting is not permitted, but it is not possible to prevent venting entirely, as for safety reasons it may be necessary in some circumstances. Where gas has to be released for technical reasons of where there is no economic use for it the preferred alternative is that the gas should be flared to reduce its contribution to global warming emissions.

It is possible that methane could escape from well heads without being flared leading to concerns that even small leakages could contribute to green-house gases. The global warming potential of a molecule of methane is greater than that of carbon dioxide, but its lifetime in the atmosphere is shorter. On a 20-year timescale, the global warming potential of methane is 72 times greater than that of carbon dioxide. As a result of these concerns the DECC report indicates that the carbon footprint of

shale gas operations have been the subject of a number of reports and significant controversy. It cites the most recent comprehensive review of the evidence by consultants to the European Commission which concluded that even on the worst case assumptions, the carbon footprint of shale gas is likely to be substantially less than that of coal; and with the application of good industry practice, is likely to be only a few percentage points greater than that of conventional gas.

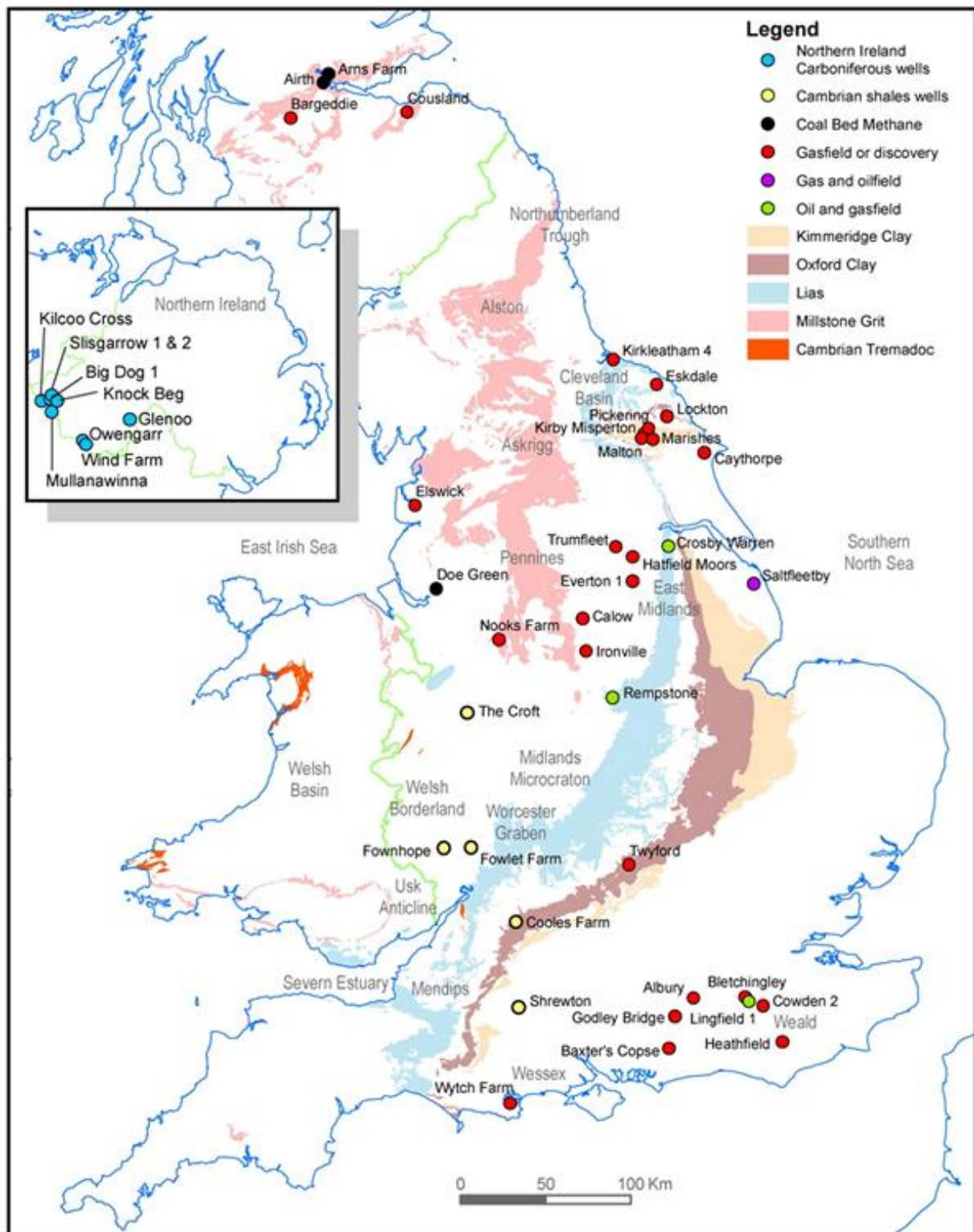
5.8 Other Pollution Risks

As a mining operation it is inevitable that hydraulic fracturing will generate mining wastes. Dependent upon the content of the wastes it is possible that the substances involved could pollute the surrounding land or atmosphere. The Environment Agency controls the management of waste and is responsible for ensuring extractive wastes do not harm human health and the environment. This is regulated by the Environment Agency through the Waste Management Plan submitted by the operator as part of the permit approval.

6 Geology

- 6.1 Large areas of the United Kingdom are underlain by shales (see map below). The body of shale which is of particular interest to Derbyshire is that known as the Bowland-Hodder shale resource. This area extends from Lancaster in the north-west across to Scarborough in the north-east. The broadly rectangular area extends as far south as Derby and Loughborough. These marine shales were deposited in a complex series of tectonically active basins across central Britain during the Visean and Namurian epochs. The shales attain thicknesses of up to 5,000 metres in the basin depocentres.
- 6.2 Not all shales are capable of producing gas. The presence of gas within the shale is a function of the organic content of the rock and how the shale was formed. Some shales did not contain enough organic material when first buried, some have not been sufficiently buried and heated whilst some hold gas but cannot sustain sufficiently high rates to be commercial. The organic content of the Bowland-Hodder shales is typically 1 to 3% but can reach as high as 8%. Accordingly the area is

considered to have a very high potential for shale gas prospects. The Jurassic Weald basin in the south of England is also known to contain commercially viable reserves. Other geological areas with commercial potential include the Kimmeridge Clay of the Weald Basin, the deeper Dinantian shales in the Pennine Basin and possibly the Oil-Shale Group of the Midland Valley of Scotland. Further reserves may be found in the Upper Cambrian source rocks on the Midland Microcraton – although it hasn't been severely tectonised and the Upper Cambrian has not sourced conventional fields. The risk attached to black shales within the Caledonian and Variscan fold belts is likely to be unacceptably high. These fold belts have high organic carbon, but are strongly tectonised (affected by thrusts, cut by igneous intrusions and converted to slates), and they have no overlying fields.



Outcrop of main black shale formations in UK and selected oil and gas wells and gas fields.

Principal UK Onshore Hydrocarbon Provinces – DECC, Hydrocarbon Prospectivity of Britain's Onshore Basin, 2010

7 Production, Consumption and Reserves

7.1 Global

For geological reasons, shale gas resources are often synonymous with sources of conventional hydrocarbon resources of oil and other gases. There are believed to be large resources of shale gas in China (1,275 trillion cubic feet), USA (862 TCF), Argentina (774 TCF) and Mexico (681 TCF). Other significant reserves are believed to exist in South Africa, Australia and several countries along the northern coast of the African continent. In Europe extensive reserves can be found in Poland (187 TCF) and France (180 TCF).

The working of shale to obtain gas to date has largely been confined to the United States where it has been extracted using various techniques. The earliest workings were in 1821 in Fredonia, New York where shallow shales were exploited. The technique of horizontal drilling began in the 1930s and a well was first 'fracked' in 1947. Production of gas using the modern methods of hydraulic fracturing generated 1,293 billion cubic metres in 2007 and this rose to 7,994 billion cubic metres by 2011. As a result of this domestic production gas imports to the USA fell by 55% between 2007 and 2012 and by 2020 it is forecast that the country will be a net exporter of gas.

7.2 National

Preliminary testing for shale gas began in the UK in 2010 but as yet no sites are producing gas using hydraulic fracturing techniques. The level of reserves is subject to ongoing investigation. The British Geological Survey study estimated that the reserves in the Bowland-Hodder study area to be in the order of 1,300 trillion cubic feet but it is not yet possible to provide a reliable estimate of the volume that could be commercially viable. The Government has acknowledged that only when empirical data is available from production sites will the figures on genuine resource availability be finalised.

The Government's Gas Generation Strategy states that, "overall, it is likely the pace of development of shale gas in the UK will be slower than has been seen in the United States. If exploration is successful, early production is likely to be seen in the second half of this decade, but any substantial contribution to the UK's gas supply is unlikely until further into the 2020s".

7.3 Derbyshire

The Bowland-Hodder study area included most of Derbyshire but it does not contain any specific information or estimates of the level of reserves in the area. It does indicate however, that parts of the County may prove to be underlain by commercially viable reserves of shale gas.

Glossary of Hydrocarbon Related Terms

Hydrocarbon – in organic chemistry a hydrocarbon is an organic compound of hydrogen and carbon. The majority of hydrocarbons found on earth naturally occur in crude oil, where decomposed organic matter provides an abundance of carbon and hydrogen which, when bonded can catenate (linkage of atoms of the same element into longer chains) to form seemingly limitless chains. The number of carbon atoms in a hydrocarbon compound determines its physical properties. For example, simple compounds such as methane have boiling temperatures below 0 degrees Centigrade and are therefore gases under ambient conditions. Larger, more complex hydrocarbon compounds are liquids under ambient conditions, whilst even larger compounds with a high molecular weight can form waxy solids.

Conventional Hydrocarbons - are oil and gas where the reservoir is sandstone and limestone.

Unconventional Hydrocarbons - refers to oil and gas which comes from sources such as shale or coal seams which act as the reservoir.

Crude Oil - is the term for unprocessed oil as it comes out of the ground. Crude oil varies in viscosity, from a water level of consistency to almost a solid. Typically, crude oil consists of 84% carbon and 14% hydrogen.

Total Resources – the estimated total volume of oil and gas physically contained in the rock. One measure of total resources used commonly, including by the British Geological Survey, is the Gas in Place (GIP) which is an estimate of the total amount of gas that is trapped within shale rock.

Reserves – the amount of resources that are deemed to be technically and commercially recoverable.

Technically Recoverable Resource – the estimated volume of oil or gas that it possible to extract from the total resource if not constrained by economics (and therefore larger than the reserves estimate).

Petroleum – literally translates from Greek origins as ‘rock oil’. The name petroleum covers both naturally occurring unprocessed crude oil and petroleum based products that are made up from refined crude oil. In base form it is a naturally occurring, yellow-to-black liquid found in geological formations beneath the earth’s surface. After water, it is the second most abundant liquid on earth. Petroleum consists of hydrocarbons of various molecular weights and other liquid organic compounds. Petroleum is a fossil fuel and is formed when large quantities of dead organisms, usually zooplankton and algae, are buried beneath sedimentary rocks and subjected to intense heat and pressure.

Fossil Fuels – are formed by natural processes such as anaerobic decomposition of buried dead organisms. The age of fossil fuels is typically millions of years, and sometimes exceeds 650 million years. Fossil fuels contain high percentages of carbon and include coal and natural gas.

Coalification – the formation of coal from a variety of plant materials via biochemical and geochemical processes.

Natural Gas - is a form of fossil fuel and is formed when layers of buried plants and animals are exposed to intense heat and pressure over thousands of years. The energy that plants originally obtained from the sun is stored in the form of chemical bonds in natural gas. Most natural gas was formed by one of two mechanisms: biogenic and thermogenic.

Biogenic Gas – is gas created by methanogenic organisms in marshes, bogs and shallow sediments.

Thermogenic Gas - is also created from buried organic material but deeper in the earth at greater pressure and temperature. Natural gas is found in deep underground rock

formations or associated with other hydrocarbon reservoirs in coal beds and as methane clathrates (chemical substance consisting of a lattice that traps or contains molecules).

Barrel of Oil Equivalent (BOE) – a term used to summarise the amount of energy that is equivalent to the amount of energy found in a barrel of crude oil. There are 42 gallons (USA gallons) in one barrel of oil, which will contain approximately 5.8 million British Thermal Units (MBtus) or 1,700 kilowatt hours (kWh). The term is used frequently when exploration and production companies are reporting the amount of reserves they may have and allows an assessment of the total amount of energy that a firm has access to, without breaking it down into barrels of crude oil, or the cubic feet of natural gas.

Porosity – or void fraction is the measure of the void spaces in a material, and is a fraction of the volume of voids over the total volume, between 0 and 1 or as a percentage between 0 and 100. The porosity of coal bed reservoirs is usually very small, ranging from 0.1 to 10%.

Adsorption Capacity – the adsorption capacity of coal is defined as the volume of gas adsorbed per unit of coal, usually expressed in SCF (standard cubic feet, the volume at standard pressure and temperature conditions) gas/ton of coal.

Fracture Permeability – acts as the major channel for gas to flow. The higher the permeability, the higher the gas production.

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