Chartered Institute of Environmental Health

Briefing Note

Hydraulic Fracturing:

Impacts on the Environment and Human Health

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1.0 Background and Purpose

The aim of this briefing paper is to summarise current best available evidence on any potential environment and health impacts of hydraulic fracturing (fracking). This includes an analysis of the scientific/technical process itself as well as actual cases and incidents.

There is currently significant commercial interest in fracking operations within, and around, the Fermanagh area of Northern Ireland, in Wales and in Lancashire. At present, there are no shale gas operations within either Northern Ireland or Wales. Operations expected to start in the UK in January, 2012 are still suspended following two small-scale earthquakes in Lancashire that have been attributed to fracking.

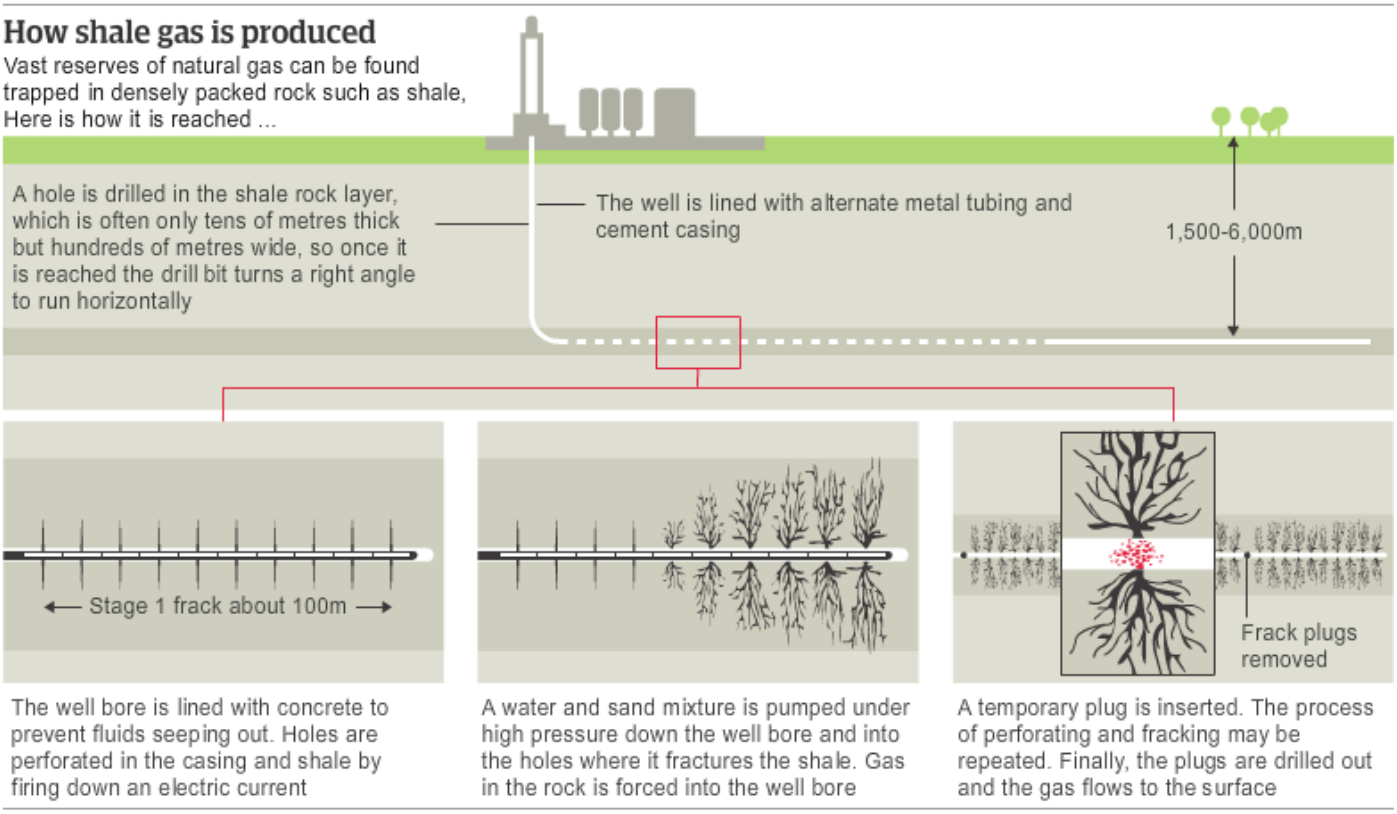
This briefing deliberately does not seek to take a position as to whether or not fracking should proceed. CIEH recognises the potential benefits associated with the process in terms of the economy, jobs and energy security. However benefits need to be balanced against potential risks and adverse impacts and it is hoped that this document will provide a summary of those from an environmental health perspective. We hope that this will in turn assist in informing future decision making.

2.0 Detail

Major fracking operations are currently limited to North America. However, legislation in the US does not require companies to state the chemical composition of fracking fluids, leading to difficulties in studying the connection between fracking and impacts upon human health and the environment.

The USA's Environmental Protection Agency's research programme is trying to uncover the full environmental and health-related implications of fracking; this research will underpin a report by the organisation that is expected towards the end of 2012. The US states of New York and New Jersey currently have moratoriums on fracking until EPA's findings are disclosed later this year.

France, Bulgaria and South Africa are the only countries to currently have suspended the search for shale gas until research uncovers the potential long-term impacts upon human health and the environment.



The Guardian, 2011[1]

3.0 Environmental Impacts

3.1 Impacts on the Water Supply

3.1.1 Millions of gallons of water are used in the process of fracking, leading to concerns over the depletion of land and ground water resources in local ecosystems. Each well requires up to 8million gallons of fracturing fluid and each well may have to be fractured more than once during its lifetime.[2] However, compared to other energy sources, the use of water for natural gas production through fracking is minimal- only 10% of what it would require to produce a comparable amount of energy from coal.[3]

[1] The Guardian, 2011. *Shale gas fracking – the facts and figures.* Available at: http://www.guardian.co.uk/environment/interactive/2011/apr/26/shale-gas-hydraulic-fracking-graphic

[2] Binns, C., 2010 "Instant Expert: Unnatural Gas." *Popular Science*. pp. 62-63
[3] Kirker, K.A.. and Burger, R.N., 2011. *"Just the Fracking Facts"*. Available at: http://136.142.82.187/eng12/history/spring2011/pdf/1267.pdf

3.1.2 Many deposits of shale are buried aquifers; if the cement casing which seals the wellhole is not adequate, the drilling process can release chemicals into the aquifer through leaks and spillages. Drinking water can also become contaminated when the fracking fluid escapes into nearby aquifers through fractures caused by drilling.[4]. Chemicals can pass from the fracture through underground pathways, likely through several aquifers due to the depth of shale gas deposits.

Case Study[5]

> Inadequate casing was cited for the contamination of groundwater in Garfield County, Colorado in 2004. The fluid, containing dangerously high levels of benzene, travelled almost 1,200m vertically, and 600m horizontally, emerging as a seep bubbling into a stream.

3.1.3 Leaks of methane, contained within the ground and released through the drilling process, can occur. This could then pose a risk of fires or explosions. The disturbance can also lead to the gas leaking through the ground into nearby wells, contaminating drinking water.[6]

Case Study[7] [8]

> 68 drinking water samples from New York and Pennsylvania confirmed methane contamination, with higher concentrations of methane the closer the proximity to shale gas wells. A 2011 study from Duke University found high levels of methane (17 times higher near shale gas drilling than any other area) in shallow drinking wells.

3.1.4 The mixture of water, sand and chemicals that is pumped into underground rock formations gradually returns to the surface, called 'flowback', where it can contaminate land and water. There have been over a thousand documented cases of

[4] New York State Department of Environmental Conservation Division of Mineral Resources., 2009. "*Draft Supplemental Generic Environmental Impact Statement on the Oil Gas and Solution Mining Regulatory Program."* Available at: http://www.dec.ny.gov/data/dmn/rdsgeisfull0911.pdf

[5] Wood, R. Gilbert, P. Sharmina, M. Anderson, K. Footitt, Glynn, S. Nicholls, F. A.. 2011*." Shale Gas: A provisional assessment of climate change and environmental impacts."* The Tyndall Centre. Commissioned by the Co-operative Group." Available at: http://www.tyndall.ac.uk/sites/default/files/tyndall-coop_shale_gas_report_final.pdf

[6] Lustgarten, A., 2008. "Buried Secrets: Is Natural Gas Driling Endangering U.S. Water Supplies?" *ProPublica*. Available at: http://www.propublica.org/article/buried-secrets-is-natural-gas-drilling-endangering-us-water-supplies-1113

[7] Osborn, S.G., Vengosh, A., Warner,N.R. and Jackson, R.B., 2011. "Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing". *PNAS*, 180(20), Available at: http://www.nicholas.duke.edu/cgc/pnas2011.pdf

[8] Osborn, S.G., Vengosh, A., Warner,N.R. and Jackson, R.B., 2011. "Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing". *PNAS*, 180(20), Available at: http://www.nicholas.duke.edu/cgc/pnas2011.pdf

water contamination near drilling sites.[9]. The mixture returning to the surface can be highly saline, containing solids and formation metals, such as flakes of rock, brines

and heavy metals which lead to difficult and expensive wastewater treatment processes.[10] Depending on the site, between 15-80% of the fracking fluid injected into the well is recovered at the end of the process..[11]

Case Study[12]

A New York Times study found that 116 of 240 wells within Pennsylvania and West Virginia had radiation levels over a 100 times the EPAs drinking water standard, with 15 of the wells experiencing levels thousands of times the recommended safe standard.

3.2 Impacts on the Quality of Air

3.2.1 Near the end of the fracking process there is a method called 'flaring' that is used to dispose of the waste gas that can't be used. The excess gas is set alight, burning until the gas disappears, sometimes taking days. This process emits noxious gases into the atmosphere. Dependent upon the scale of flaring, this could include harmful levels of methane, sulphur dioxide, volatile organic compounds and oxides of nitrogen.[13]

3.2.2 Fracking emits 50% less carbon dioxide than coal mining and 30% less than oil drilling, yet carbon is still emitted in the process – it created a fifth of energy-related US carbon emissions in 2008. [14] Methane, a potential by product of the process, released as a result of the drilling, is also a greenhouse gas and is considered to be 30 times more potent than carbon dioxide.[15] Researchers at Cornell University found that 1.3 to 2.1 times more methane can be emitted during the fracking process,

[9] Lustgarten, A., 2008. "*Buried Secrets: Is Natural Gas Driling Endangering U.S. Water Supplies?" ProPublica*. Available at: http://www.propublica.org/article/buried-secrets-is-natural-gas-drilling-endangering-us-water-supplies-1113

[10] Harvey, F., 2011. "*Shale gas fracking – Q&A*" The Guardian. April 20, 2011
[11] Environmental Protection Agency, 2010. "*Hydraulic Fracturing Research Study."* Available at: http://www.epa.gov/owindian/tribal/pdf/hydraulic-fracturing-fact-sheet.pdf
[12] Food & Water Watch., 2011. "*The Case for a Ban on Gas Fracking*" Available at: http://documents.foodandwaterwatch.org/frackingReport.pdf
[13] Energy and Climate Change Commission., 2011. "*Shale Gas".* HC 795, 2010-2012, London: HMSO
[14] U.S. Energy Information Administration., 2009 "*Emissions of Greenhouse Gases in the U.S. 2008 Overview."*
[15] Bracmort, K., et al., 2009. Congressional Research Service. "*Methane Capture: Options for Greenhouse Gas Emission Reduction".* National Science Foundation.

compared to conventional gas production. Therefore, over a 20 year period, shale gas production would emit 20-100% more greenhouse gases than coal mining.[16]

3.3 Geological Impacts

3.3.1 The injection of water and chemicals into the ground at high pressure can lead to seismic activity.

Case Study[17] [18]

> Two small-scale earth tremors around the area of Singleton in Lancashire have been attributed to fracking activities, based on a report commissioned by Cuadrilla Resources – the company responsible for the hydraulic fracturing operations in the area. Drilling was suspended immediately after the tremors were recorded in April and May, 2011 in order for further investigations to take place. Small tremors felt in Arkansas, Oklahoma, Texas, British Columbia and other areas of the US that are usually seismically inactive have been attributed to hydraulic fracturing.

4.0 Human Health Impacts

4.1 Water Consumption

4.1.1 Many of the chemicals used in hydraulic fracturing can cause eye, skin and respiratory problems and can also affect the brain, nervous system and gastrointestinal system.[19].

[16] Howarth, R.W., 2011. "*Assessment of the Greenhouse Gas Footprint of Natural Gas from Shale Formations Obtained by High-Volume, Slick-Water Hydraulic Fracturing".*Available at: http://www.technologyreview.com/blog/energy/files/39646/GHG.emissions.from.Marcellus.Shale.April12010%20draft.pdf

[17] Jowit, J. and Gersmann, H., 2011. "*Fracking 'probable' cause of Lancashire quakes".*, Available at: http://www.guardian.co.uk/environment/2011/nov/02/fracking-cause-lancashire-quakes

[18] Fountain, H., 2011. "*Add Quakes to Rumblings Over Gas Rush"* . New York Times. Available at:http://www.nytimes.com/2011/12/13/science/

[19]Safe Drinking Water Founation., 2011. "*Fracking".* Available at: http://www.safewater.org/PDFS/knowthefacts/Fracking.pdf

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Case Study[20]

> 5 months after Equitable fractured their third well in West Virginia, residents on a property 1000ft south of the site complained that their usually clear water had turned brown and led to weakness, headaches, nausea and burning eyes. Residents on a neighbouring farm suffered from similar illnesses and the loss of 93 farm animals.

4.1.2 A number of potentially harmful chemicals are used in the fracking process, including hydrochloric acid, methanol, formaldehyde amine, benzene[21] and naphthalene[22] Cuadrilla, the only organisation within the UK to release natural gas through fracking, state that their fracking fluid comprises 99.795% water.[23]. Although the chemicals used comprise a tiny percentage of the liquids used in the drilling process, the quantities of fluid used are so large that there could be thousands of gallons of chemicals in the waste.[24]

Case Study[25]

> Scientific analysis in Texas has revealed high levels of benzene in the air after many local residents and animals suffered from unexplained sickness and neurological defects soon after drilling started.

4.1.3 There have been a number of cases of drinking water contamination allegedly caused by hydraulic fracturing. There is a report anticipated from the US EPA this year, as mentioned earlier in this briefing note, which we understand will comprehensively address this issue.

Case Study[26]

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[20] Horwitt, D., 2011. " *Cracks in the Facade".* Environmental Working Group. Available at: http://static.ewg.org/reports/2011/fracking/cracks_in_the_facade.pdf
[21] Range Resources., 2010. "Well Completion Reports." *Range Resources*. Available: http://www.rangeresources.com/getdoc/
[22] Oil and Gas Accountability Project ., 2005. "*Our Drinking Water at Risk."* Available at: http://www.earthworksaction.org/files/publications/DrinkingWaterAtRisk.pdf
[23] Cuadrilla Resources., no date. "*Fracturing Fluids".* Available at: http://www.cuadrillaresources.com/what-we-do/technology/fracturing-fluid/
[24] Soeder, D.J. and Kappel, W.M., 2008. *"Water Resources and Natural Gas Production from the Marcellus Shale"* Available at: http://pubs.usgs.gov/fs/2009/3032/pdf/FS2009-3032.pdf
[25] Lee, M., 2009. "*State worried about air pollution near Barnett Shale wells".* Star-Telegram Available at: http://www.istockanalyst.com/article/viewiStockNews/articleid/3659468
[26] Horwitt, D., 2011. " *Cracks in the Facade".* Environmental Working Group. Available at: http://static.ewg.org/reports/2011/fracking/cracks_in_the_facade.pdf

Shortly after EXCO Resources began production in Jackson County, West Virginia in 2006 two water wells became polluted, with the water changing in both colour and consistency. Shortly after the contamination, water was delivered to the affected residents. Many of the landowners whose water was contaminated refused to comment on the matter after signing confidentiality agreements with EXCO. This has led to difficulty in uncovering the full implications of fracking activities.

Fractures can be a side-effect of production, allowing hydrocarbons, brine and fracturing fluid from the well to contaminate nearby drinking water.[27] Natural spring water is a precious resource in Fermanagh that could be compromised by shale gas production.

Case Study[28]

The British Columbia Oil and Gas Commission reported 18 cases of invasive fluids entering adjacent gas wells in British Columbia, and one case in Western Alberta. The fluids included water, CO2, sand, nitrogen, drilling mud, gas and other stimulation fluids.

4.2 Other Health Impacts

4.2.1 A 2011 research paper confirmed that methane can leak from the shale layer into wells and nearby aquifers.[29] Methane leaks from drilling sites has caused neighbouring houses and wells to explode, leading to many cases of loss of property, injuries, and even deaths in the US.[30]

Case Study[31]

[27] Horwitt, D., 2011. " *Cracks in the Facade".* Environmental Working Group. Available at: http://static.ewg.org/reports/2011/fracking/cracks_in_the_facade.pdf
[28] Horwitt, D., 2011. " *Cracks in the Facade".* Environmental Working Group. Available at: http://static.ewg.org/reports/2011/fracking/cracks_in_the_facade.pdf
[29] Jackson et al, 2011. "*Research and Policy Recommendations for Hydraulic Fracturing and Shale-Gas Extraction"* Center on Global Change, Available at: http://www.indyweek.com/pdf/051111/dukefrackingrecommend.pdf
[30] Lustgarten, A., 2008. "*Buried Secrets: Is Natural Gas Drilling Endangering U.S. Water Supplies?" ProPublica*. Available at: http://www.propublica.org/article/buried-secrets-is-natural-gas-drilling-endangering-us-water-supplies-1113
[31] Wood, R. Gilbert, P. Sharmina, M. Anderson, K. Footitt, Glynn, S. Nicholls, F. A.. 2011.*" Shale Gas: A provisional assessment of climate change and environmental impacts."* The Tyndall Centre. Commissioned by the Co-operative Group." Available at: http://www.tyndall.ac.uk/sites/default/files/tyndall-coop_shale_gas_report_final.pdf

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Methane gas collected in a water well vault in Pennsylvania during 2009, leading to the contamination of a freshwater aquifer and an explosion at the surface.

4.2.2 US Federal law does not require companies to report the chemical composition of the fracking fluid to the EPA. However, a 2011 study[32] suggests that:

- 25% of the chemicals used in the fracking fluid could potentially cause cancer.
- 37% of these chemicals could upset the endocrine system.
- 40-50% of the chemicals found could affect the nervous, immune and cardiovascular systems.
- 75%+ could irritate the eyes, skin and respiratory system.

A large proportion of the chemicals used in the fracking fluid have not been tested for safety in humans, especially for long-term effects upon the nervous and endocrine systems. Even low level exposure to the chemicals in drinking water may have a significant impact upon the endocrine system.[33]

4.2.3 Benzene, a known carcinogen, is found within most fracking fluids. A study found some fracking fluid samples contained 93 times more benzene than is found in diesel; enough for one well to contaminate over a billion gallons of drinking water.[34] A recently published report by the University of Texas' 'Energy Institute' highlights the use of thirteen known carcinogens in the fracturing fluid used by US drilling companies, including benzene and naphthalene. The composition of fracturing fluids is now in review 6 years after production started in the US. The chemical 2-BE is now being replaced due to findings that it destroys red blood cells, whilst also causing damage to the spleen, liver and bone marrow.[35]

[32] Colborn, T., Kwiatkowski, C., Schultz, K. and Bachran, M., 2011. "Natural Gas Operations from a Public Health Perspective." *International Journal of Human and Ecological Risk Assessment,* Available at: http://www.endocrinedisruption.com/files/Oct2011HERA10-48forweb3-3-11.pdf

[33] Environmental Health Association of Nova Scotia., 2011. "*Health Impacts of Fracking: Submission to Review of Hydraulic Fracturing for Shale Gas in Nova Scotia* " Available at: http://www.environmentalhealth.ca/frackingscopehealthjune2011.pdf

[34] Horwitt, D., no date. "*Drilling Around the Law".* Environmental Working Group, Available at: http://static.ewg.org/files/EWG-2009drillingaroundthelaw.pdf.

[35] Groat, C.G. and Grimshaw, T.W., 2012. *Fact-Based Regulation for Environmental Protection in Shale Gas Development.* The Energy Institute. Available at: http://energy.utexas.edu/images/ei_shale_gas_regulation120215.pdf

4.2.4 Case Study[36]

> Seven workers were burned in West Virginia when a well exploded. The piece that caused the explosion, ironically called the 'blowout preventer', was the same piece that failed to prevent the BP oil spill in Mexico, leading to many critics speculating that fracking will lead to the next big environmental disaster.

4.2.5 Shale gas production has also been recorded to cause photochemical smog.

Case Study[37] [38]

> Sublette County in Wyoming, an area with a high concentration of shale gas wells, recorded levels of ozone higher than those found in Los Angeles. This is thought to be the reason behind high levels of asthma in children in this area – three times higher than the state average. Residents also complained of watery eyes, bloody noses and shortness of breath, symptoms occurring regularly over a four year period.

5.0 Other Impacts

5.1 Naturally occurring radioactive material (NORMs), such as uranium, benzene and thorium are present in shale. The radioactivity of these materials can become concentrated because of pressure and/or temperature changes during the drilling process. While the radioactive levels are relatively low, there is still a real safety issue in containing, transporting and disposing of the material.[39] People and animals can then become exposed to the radioactive material when it is stored in wastewater ponds, before disposal.[40] These factors must be taken into account in areas of the UK where there are known to be high levels of NORMs that could be disrupted through the fracking process.

[36] Maykuth, A, 2010. "*Pa. suspends gas drilling at Marcellus rupture site.*" The Philadelphia Inquirer. Available at: http://articles.philly.com/2010-06-07/news/24962179_1_eog-resources-natural-gas-drilling-fluid
[37] Food & Water Watch., 2011. "*The Case for a Ban on Gas Fracking*" Available at: http://documents.foodandwaterwatch.org/frackingReport.pdf
[38] Environmental Health Association of Nova Scotia., 2011. "*Health Impacts of Fracking: Submission to Review of Hydraulic Fracturing for Shale Gas in Nova Scotia* " Available at: http://www.environmentalhealth.ca/frackingscopehealthjune2011.pdf
[39] Kargbo, D., Wilhelm, R. and David J. Campbell, D.J., 2010. "Natural Gas Plays in the Marcellus Shale: Challenges and Potential Opportunities." *Environmental Science & Technology*. Available: http://pubs.acs.org/doi/full/10.1021/es903811p
[40] Environmental Health Association of Nova Scotia., 2011. "*Health Impacts of Fracking: Submission to Review of Hydraulic Fracturing for Shale Gas in Nova Scotia* " Available at: http://www.environmentalhealth.ca/frackingscopehealthjune2011.pdf

Case Study[41]

Samples taken by the Environmental Agency from a shale gas site during 2011 in Lancashire found low levels of naturally occurring radioactive minerals along with high levels of sodium, chloride, iron, bromide, lead, magnesium and zinc.

5.2 Hydraulic fracturing often involves the transportation of equipment and chemicals to remote areas. Rural road damage and traffic congestion have been highlighted as problems arising from the transportation of equipment to shale gas sites.[42] Local watersheds and rivers may deteriorate through the build-up of sediment, as erosion occurs from increased traffic on rural roads. Similar problems may also arise through drill pad and pipeline construction.

5.3 Increased use on roads in rural areas and the construction of pipelines may alter the local ecosystem, for example the relationships between predator and prey, resulting in changes to species composition.[43]

5.4 The large sites necessary for shale gas production have the potential to cause significant visual and noise disturbances to local communities. A sufficient level of production requires a large number of wells, large volumes of water stored in on-site reservoirs, a pond for contaminated waste, storage tanks and a compressor station. Disturbances to the landscape will also be attributed to large volumes of traffic transporting goods to and from the site.

Case Study[44]

The Forest of Dean District Council refused planning permission for the production of shale gas in 2007 due to negative impacts upon the appearance of the landscape, although permission was granted at a neighbouring site in 2010.

[41] Environment Agency., 2011. *"North West - Monitoring of Flowback water."* Available at: http://www.environment-agency.gov.uk/static/documents
[42] Soeder, D.J. and Kappel, W.M., 2008. *"Water Resources and Natural Gas Production from the Marcellus Shale"* Available at: http://pubs.usgs.gov/fs/2009/3032/pdf/FS2009-3032.pdf
[43] The Pembina Institute, 2008. "*Coalbed Methane and Salmon: Assessing the Risks".* Available at: http://www.pembina.org/pub/1635
[44] Deutsche Bank, 2011. "*European Gas: A First Look At EU Shale-Gas Prospects."* Available at: http://longfinance.net/images/reports/pdf/db_shale_2011.pdf

About the CIEH

The Chartered Institute of Environmental Health is a professional, awarding and campaigning body at the forefront of environmental and public health and safety.

The Chartered Institute of Environmental Health (CIEH) is a registered charity and the professional voice for environmental health. It sets standards, accredits courses and qualifications for the education of members and other environmental health practitioners.

It provides information, evidence and policy advice to local and national government and environmental and public health practitioners in the public and private sectors. As an awarding body, the CIEH provides qualifications, events, and support materials on topics relevant to health, wellbeing and safety to develop workplace skills and best practice.

As a campaigning organisation, the CIEH aims to promote improvements in environmental and public health policy. It is based in the UK with offices in London, Belfast and Cardiff.