APPEAL BY ISLAND GAS LTD, PORTSIDE
ELLESMERE PORT

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GEOLOGY

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Submitted on behalf of Frack Free Ellesmere Port and Upton
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1. Introduction

1.1 My name is Robin Francis Grayson. I am a senior consultant in geology and environment. My main client this year has been the United Nation’s Development Program (UNDP), a branch of the World Bank Group, advising them on mineral resources in Afghanistan. This is a home-based follow-on to my many assignments in-country in Afghanistan for the World Bank, USAID, GIZ in mineral resources notably delivering high-level training to the Afghanistan Geological Survey, leading studies in copper, silver, gold, iron, talc, gemstones etc. From time to time I have assisted in developing national legislation on mining, and assisted the Petroleum Authority of Afghanistan.

1.2 I hold an Upper Second Class Honours Degree in Geology and Zoology with subsidiary Botany from the University of Manchester, followed by a 3-year postgraduate scholarship at Manchester awarded by the National Environmental Research Council. During tenure, I was awarded a Master’s Degree in Geology by research on the buried bedrock topography between Manchester and the Mersey Estuary, in which I gathered and analysed the logs of several thousand boreholes, including many from the Ellesmere Port, Stanlow and Wirral Peninsula. I also discovered and described the freshwater Eccles Mudstone as a unit on top of the Manchester Marl (EP16).

1.3 My first employment was as Well-Site Geologist for the Holme Chapel-1 wildcat well which disproved the Geophysicist's interpretation of the vibroseis lines. The strata drilled were of exactly the same age as encountered in Ellesmere Port-1, and drilled through both the Thieveley Lead Mine Fault and the Deerplay Fault, and loss circulation occurred several times due to leaching and joints associated with the faulting.
1.4 For a decade I was Lecturer in Geology at Wigan and District Mining & Technical College and Secretary of the Wigan & District Geological Society. Due to intensive fieldwork I became a leading expert in the regional geology of the Carboniferous sequence of North-West England and North Wales. As a result, I became Senior Consultant with Oldham Associates through which I became Adviser to more than twenty exploration companies engaged in exploration for oil and gas in North-West England and offshore in the East Irish Sea Basin, and the East Midlands Oilfields. Notable clients of mine included Amoco, British Petroleum, Britoil, Enterprise Oil, Lennox, Edinburgh Oil and Gas, and Marinex Petroleum. I introduced predictive exploration methods and helped my clients interpret many hundreds of miles of seismic.

1.5 Relevant to Ellesmere Port-1, the seismic data indicated hundreds of square miles of deeply buried anhydrite (CaSO$_4$) evaporites near the base of the Mississippian (‘Carboniferous Limestone’ sensu lato), capable of generating large volumes of sulphate groundwater which in contact with sweet gas would result in sour gas due to generation of large volumes of toxic hydrogen sulphide (H$_2$S) in solution. H$_2$S therefore poses a particular threat to the economic viability and environmental health and safety of Ellesmere Port-1 if leaching or fracking were to be attempted. In this regard, I am lead author of an ongoing major study addressing the risk of gas exploration in North-West England. I anticipate this will be published in early in the New Year. An abstract of the draft may be found in Appendix 1.

1.6 In my career I have been Team Leader of major international projects in Albania, Mongolia, Kazakhstan, Kyrgyzstan and Afghanistan including developing major coal mines and gold mines in the Gobi Desert, mapping silver, gemstones, jade, talc and lapis lazuli in the Hindu Kush, and more locally been an Expert Witness at a number of public inquiries in the Wigan area regarding opencast coal proposals, and was a leading Expert
Witness in the major public inquiries regarding construction of the Second Runway at Manchester International Airport.

1.7 The evidence in this proof of evidence is true to the best of my knowledge and belief. I confirm that the opinions expressed are my true and professional opinions. I am fully aware of my duty to the Inquiry and I will provide my honest and professional view.
2. Context

2.1 This proof of evidence is largely based on geological information I obtained as a result of work I did on behalf of my clients, consisting of more than 20 oil and gas exploration companies who purchased Report 84/4 from Oldham Associates in 1984: “Prospects and Plays in North-West England and the East Irish Sea Basin.” This was the leading report guiding oil and gas exploration in the region at that time. Report 84/4 is now on open file on the website of the UK Onshore Geophysical Library (UKOGL).

2.2 Significant to this Inquiry is that Oldham Associates screened the Wirral and surrounding areas, and rejected the Wirral and Ellesmere Port as being non-prospective for conventional oil and gas.

2.3 Significant too is that the major oil company Shell, who were not among my clients (unlike British Petroleum, Enterprise Oil etc.), held the exploration licences for the Wirral, and identified five possible hydrocarbon prospects but ranked Ellesmere Port to be of no interest, even though they had a network of seismic lines, including one along the major road past where Ellesmere Port-1 was later drilled. Shell then relinquished their licences for the Wirral without drilling a single hole. To clarify, 20 exploration companies wrote off Ellesmere Port as being unattractive, and Shell held the exploration licence but surrendered it without drilling any of five prospects they had identified, and the five did not include Ellesmere Port.

2.4 FFEP&U asked the current licence holder, IGas, to provide the geological information that obtained in 2014 when the well was drilled. IGas had that information when FFEP&U made its request on 23 October 2018 and it was easily transmissible in electronic form. The confidentiality period on disclosure of the information in fact runs out on 1 January 2019, after which some of it will become available in the public domain via the UK Onshore Geophysical Library (UKOGL). Despite this, IGas only provided the information on 23 November 2018.
2.5 It will take some time to assess the 2014 data. As soon as I have been able to undertake that assessment, I will provide an addendum to this proof of evidence setting out my analysis.
3. Nature of Resource

3.1 FFEP&U also asked IGas to clarify the development it intends to carry out if planning permission is granted. By letter dated 5 November 2018, IGas stated that “the Pentre Chert is a conventional resource.” (EP23) When FFEP&U challenged this, IGas responded by letter on 22 November 2018, stating:

“With regard to the permeability of the Pentre Chert, this is of course a matter to be explored as part of the proposed development. However, as set out in Section 2.4 of the Planning Statement submitted with the planning application, the Pentre Chert consists of fractured cherts and siliceous shales. It is also confirmed in Section 5.2.1 of the Site Condition Report, submitted in support of the environmental permit application, that the Pentre Chert comprises interbedded chert, siliceous shale and occasional sand deposits. The Appellant does not disagree with your description of the Pentre Chert being a tough, brittle rock, though we would say that it has low permeability as opposed to not being permeable. However, the Pentre Chert encountered at Ellesmere Port is considered to be naturally fractured.”

3.2 In my professional opinion, Ellesmere Port-1 is implausible as a conventional well. No oil or gas company would consider this to be a good place to drill for conventional oil and gas, as there is no significant structural trap. None of my twenty-plus oil and gas exploration company clients regarded Ellesmere Port as being worthy of discussion. When Shell took up an exploration licence for the Wirral and Ellesmere Port, they conducted intense efforts. Shell discovered five potential conventional drilling prospects in the Wirral, but none of these were in Ellesmere Port. Relevant here is that one of Shell’s seismic lines went extremely close by where Ellesmere Port-1 was later drilled, and yet Shell geologists found nothing worthy of merit there.

3.4 I have therefore assessed IGas’s position on the geology and the resource against the fully documented findings of Shell in their Relinquishment
Report now available in the public domain on the UKOGL website, in addition to the Shell seismic lines past the site of Ellesmere Port-1.

3.5. I have prepared a structure contour map of the geology (shown below) of the Wirral and Ellesmere Port area, and this confirms Ellesmere Port-1 cannot be deemed to be a plausible prospect for conventional oil or gas.

![Map of geology](image)

**Figure 1:** Results of Shell’s intensive exploration work for conventional oil and gas in the Wirral Peninsula and Ellesmere Port. Dark lines depict faults, grey area depicts prospects identified by Shell for conventional oil and gas.

3.3 As shown above, Ellesmere Port-1 was not drilled in a prospect for conventional oil and gas. In my professional judgement, Ellesmere Port-1 was drilled for unconventional oil and gas.

3.4 Returning to the issue of the Pentre Chert, it is inappropriate to regard it as being a conventional reservoir, which it is certainly not. All geologists know what chert is. Regardless of the variety or origin, all chert is SiO₂. Chert is tough to drill through because SiO₂ has a hardness of 7 on the Moh’s hardness scale, and it is readily identifiable in cuttings of oil and gas wells. Chert has zero porosity.
3.5 IGas described it as having "low permeability". That would be highly unusual. For this to be relevant, IGas will need to verify their assertion opinion with laboratory test results such as Scanning Electron Microscopy (SEM).

3.6 Chert is agreed by petroleum geologists to be an unconventional resource and while these deposits are common and important as oil and gas reservoirs in the USA, they are not known to be a reservoir in the UK.

3.7 It is important to understand whether the well is conventional or unconventional resource, in terms of scale, impacts and permitting. The government and local planning authorities require clarity in this matter, and so too do the public and all interested parties.

3.8 However, an overarching planning consideration is of greater concern. I have some knowledge of the planning process, and specifically mineral planning. For five years I was an elected member on Greater Manchester County Council (GMC). As a member, I served on the Planning and Development Committee, and took an active part in the design of the Greater Manchester Local Minerals Plan, and in determining planning applications for the development of mineral resources, including several thousand miles of seismic data for oil and gas; approval of permission for deep oil and gas exploration, opencast mining applications for coal and brick shale, and washing of mine waste to extract coal and so forth. Upon abolition of the GMC, I became an elected member on Wigan Metropolitan Borough Council serving on the Policy Committee and the Planning and Development Committee. Relevant to this inquiry, I gained high level knowledge and experience in all aspects of coal resources including coal bed methane.

3.9 My understanding is that planning permission for Ellesmere Port-1 was in order to drill a vertical hole for the express and sole purpose of production of coal bed methane. Coal bed methane is currently produced with special
licences for CBM coal bed methane issued by the government. Obviously it would be extraordinary, indeed probably *ultra vires*, for a planning authority to grant planning permission for a production well for CBM, if the well in question did not, and does not, hold an appropriate CBM licence from the government. Again it would be extraordinary, indeed *ultra vires*, for a planning authority to grant planning permission for extracting a mineral resource, namely coal bed methane, when the applicant has failed to produce any CBM in spite of drilling through what IGas regard as coal measures. In my professional judgement, there was no evidence before or after drilling, that significant coal beds are present in Ellesmere Port-1. Therefore, as there never were, and never are, significant coal beds at Ellesmere Port-1, my clear opinion is that the existing permission must be revoked as the mineral resource - CBM - for which planning permission was granted was not present.

3.10 Among other concerns is that of precedent. For if permission for a CBM well is so elastic that coal need not be present at depth at all, or that if it is then the permission holder is free to go ahead and switch to producing methane from chert, a non-coaly, non-gassy, non-oily non-inflammable non-fuel, then the government and local planning authority open the floodgates to loss of control over mineral resources. For instance, the precedent would allow, without debate, to apply for drilling for CBM anywhere and everywhere regardless of lack of evidence of coal beds being present before or after drilling. Having proved the gassy Bowland Shales instead, to then go ahead and extract the gas via brittle fractured Pentre Chert would surely fail to meet the stated purpose requirements of the initial planning permission.

3.11 As an aside, I am concerned that fractured chert is the target. This means tens of thousands of chert shards will be disturbed and many shards brought to the surface in the returned drilling mud with pyrite and any methane. Pyrite and steel can cause a spark, chert and steel can also create a spark'; flint is another name for chert and gives its name to flintlock pistols. At the surface, a dried out mix of chert shards, steel swarf and
pyrite would be a cause of concern in increasing the risk of igniting a methane explosion, blowout and fire.

3.12 Regarding the absence of significant coal beds at Ellesmere Port-1. It should be self-evident than when Liverpool rose to be the busiest port in the world in the age of steam, then geologists and their backers would scour the Wirral, and indeed Liverpool, in the hope of finding coal and becoming very rich. One of the usual signs of coal beds was missing, namely surface seepages of methane from the coal, in other words CBM bubbling at the surface. These were numerous in the South Lancashire Coalfield, and indeed Thomas Shirley gave the world’s first description of methane gas in “1666: The Description of a Well, and Earth in Lancashire, taking Fire by a Candle approached to it”¹. It was CBM. Such surface outbursts flamed for centuries. Some were tourist attractions. Many tragedies from CBM fires and explosions occurred, a few from surface outbursts of CBM and CBM in underground mines. The burning well documented in 1666 became marked on maps of the Ordnance Survey along with others. Checking the location I found it had been built over by a Vicarage and was then an Old People’s Home. Checking local newspapers of mid-1900s I came across an article: “Consternation at the Vicarage, flames through Dining Room Floor”. Of particular relevance to Ellesmere Port-1 is the remarkable ability of CBM to enter drains and follow the drains to explode under homes and factories, or in this case a Vicarage. The Fire Brigade failed to extinguish the flames by using hosepipes, and the CBM was only extinguished by a team of coal miners who trenched back to the source of the methane. Dozens more examples can be given of the danger of CBM creating fires and explosions.

3.13 Therefore if Ellesmere Port-1 were allowed to proceed, first all culverts and drains within several hundred metres from the well pad would first need to

¹ 8. Thomas Shirley 1666. The Description of a Well, and Earth in Lancashire, taking Fire by a Candle approached to it. Philosophical Transactions of the Royal Society of London 1666-1667 volume 2, pages 482-484. http://rstl.royalsocietypublishing.org/content/2/23-32/482.1.full.pdf+html
be mapped and sealed. This should have been done earlier before any drilling but it was not.

3.14 If coal beds were present underground at Ellesmere Port, then I would expect historical evidence of ‘burning wells’ due to leakage of CBM to the surface. As yet none have been brought to my attention.
4. Extracting oil and gas from Chert

4.1 Chert as an unconventional resource is made possible by any of three mechanisms:

i) If beds of solid chert have closely spaced open fractures produced by
   a) regional stress fields, or
   b) by being shatter belts of faults; or
   c) by being opened up by hydraulic fracturing

   It appears from the correspondence that IGas considers this to be the position at Ellesmere Port I.

ii) If beds of solid chert have been altered to “tripolite” i.e. chert of any age that has been highly weathered by meteoric fluids beneath unconformities, and which is light-weight because of high micro-porosity that formed during subaerial exposure prior to final reburial. Some tripolites are calcitic because of the presence of unsilicified carbonate particles or secondary calcite. In other words tripolite, which is readily identifiable in well cuttings, is a diagenetic alteration product of chert, and a good example of a very unconventional resource.

   IGas has not suggested the Pentre Chert in Ellesmere Port-1 to be a tripolite or to be a tripolite reservoir.

iii) If the term “chert” is a misnomer for solid limestone (CaCO₃) partially or wholly replaced by a tight mesh of microscopic quartz crystals. These are known at depth in NW England in close proximity to major faults, as in the Holmes Chapel-1 well drilled by a consortium of three USA companies. The major faults were missed in the seismic but proved in the drilling. Fortunately the limestone had not leached to leave just the open mesh of quartz or a blow-out would have been highly likely. Again, IGas has not suggested that this is the case.
5. Incorrect Appraisal of Seismic Data

5.1 In its documents IGas suggests that the Pentre Chert is a conventional target by virtue of being a pinch-out: (CD 4.1 the Statement of case at §2.9 and CD 2.4 the Planning Statement section 2.4, pages 11-12) which include the diagram below and conclude: “This geometry allows for an accumulation of conventionally trapped hydrocarbons within the Pentre Chert in a stratigraphic pinch out”.

![Diagram of stratigraphy](image_url)

**Figure 2** From IGas Planning Statement p12

5.2 It is important to understand whether this is plausible, both in order to test whether the resource is conventional and also to investigate whether there are any particular dangers that arise from the geology that should be taken into account in deciding whether IGas’s proposal should be granted planning permission.

5.3 IGas claim to have evidence of a pinch-out. My reappraisal of the geology of the area shows scant evidence of a pinch-out on 2-D seismic line along the highway past Ellesmere Port-1 by Shell, and the repeat of that line by confidential 3-D seismic would be wholly insufficient to determine whether a pinch-out was present at all. This is because only one seismic line route has ever been done. To prove a pinch-out would require a second route for seismic orientated, for example north-south, which IGas has chosen not to do.
5.4 Regarding the supposed pinch-out, the vicinity is criss-crossed by additional faults to those shown on the most detailed maps of the British Geological Survey – see Figure 4 below. Substantially more likely than a pinch-out would be that a false appearance of a pinch-out can commonly be caused by a seismic line being orientated tangentially to a fault plane, and there are numerous faults present at Ellesmere Port.

5.5 Regarding faults, there are at least four in close vicinity to Ellesmere Port-1 and, if no fault planes were intersected when drilling then that would have been surprising, albeit not impossible. Important to note is that in my experience a seismic line in NW England commonly shows what at first looks convincingly like a pinch out, but this impression is then dispelled by a second seismic line done roughly at right angles to the first. Time and time again it is then revealed to be a fault.

Figure 3 Seismic data lines. Solid green = 1984 survey, broken green = 2014 survey
5.6 Relevant here is that the standard 1:50,000 maps of the bedrock geology of the region by the British Geological Survey show most faults as dashed broken lines. Very small print on the BGS maps states "broken lines denote uncertainty". This caution applies to all the faults shown on the BGS map of the Ellesmere Port area.

![Figure 4](image)

**Figure 4** Location of Geological Faults from BGS. Red circles depict epicentres of tremors

5.7 Having rejected a pinch-out as impossible to prove with only a single route being shared by the public 2-D and confidential 3-D seismic lines, the high probability of the Pentre Chert being shattered by a fault in the Ellesmere Port-1 Borehole merits discussion.

5.8 In my opinion, by trying to produce gas from a fault zone in fractured chert, IGas is creating a significant risk of a sudden blowout of inflammable gas, especially if the reservoir is confined to the fractured fault zone.
6. Presence of Hydrogen Sulphide

6.1 I note that the Air Quality Impact Assessment submitted with the Planning Statement [CD 2.4 Appendix 11] states that: “The natural gas produced during the DST and EWT is not expected to contain hydrogen sulphide (H2S). This expectation is based on results from mud logging during well drilling operations to well total depth (TD) including the Pentre Chert intervals where no H2S was recorded. Sulphur dioxide (SO2), the combustion product of H2S, is therefore not included in the assessment.”

6.2 I disagree. The risk of encountering a pocket of sour gas with dangerous levels of toxic, explosive, inflammable hydrogen sulphide (H2S) is also significant. For H2S to be present in large volumes requires sweet gas to be in contact with anhydrite (CaSO4).

6.3 Only if the drilling was exclusively for CBM can the risk of encountering H2S be regarded as being negligible in NW England.

6.4 Unfortunately, by drilling far deeper than the coal measures IGas entered a completely different hazard regime, including H2S, by drilling into the older rocks of the Bowland Basin.

6.5 IGas should be aware that large areas of the Bowland Megabasin contain beds of anhydrite at depth near the base of the Mississippian. This is now realised to be the "new normal" for most of the Bowland Basin. IGas should know this, because the monitoring required by the Environmental Permit includes monitoring for hydrogen sulphide (CD 4.1 pg 9)

6.6 In order to make clear to the Inquiry the extensive and detailed nature of the evidence of anhydrite I submit Appendix 1 which is a draft Abstract of a research report in course of preparation, of which I am the lead author. A more advanced draft will be available on January 1st 2019 and publication is anticipated shortly thereafter.
6.7 It is worthy of note that in the geological past immense amounts of H$_2$S were generated in order for the beds within the Pentre Chert to become a major lead and zinc producer due to the presence of ZnS (sphalerite) and PbS (galena). It is also noteworthy that sour gas with high levels of H$_2$S dominate the offshore oil and gas fields offshore in the East Irish Sea Basin, rendering expensive treatment offshore and then again onshore at Point of Ayr (Dee) and Rampside (Barrow) to remove sufficient H$_2$S to enable the sweetened gas to be legally allowed to enter the National Gas Grid. Even then the still slightly sour gas retains sufficient H$_2$S to allegedly corrode from the inside central heating installations.

6.8 The consensus is that the source of the gas in the East Irish Sea Basin immediately off the coast of North Wales, Liverpool and Blackpool are the frackable Bowland Shales of which the various shales proved in Ellesmere Port-1 are the local representatives.\(^2\)

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7. Seismic Activity

7.1 Seismic activity is present in remarkably close proximity to the EP-1 well. Therefore IGas prior to drilling should have conducted a seismic assessment, and established a small network of local seismic stations throughout and after the drilling. IGas should, as a matter of course, submit such information to the Inquiry. IGas should put in place a seismic monitoring station several months in advance of any activity at the well, and continue the monitoring for several months after such activity ceases.

7.2 At face value, the seismic activity indicates natural faulting is active in the vicinity of Ellesmere Port-1, and therefore the possibility of triggering movements in the well are significant, increasing risk to personnel and equipment, as well as encouraging sudden unpredictable movement of fluids up the well - and equally so up fault planes and water wells in the vicinity, into sewers and storm drains, under floors of homes and into cavity walls of buildings. This risk applies not only to methane but also the explosive inflammable toxic cocktail of methane and H$_2$S.

8. Risk to local Watercourse

8.1 I will now turn to concerns expressed by the British Geological Survey (BGS) to the presence of extraordinarily high concentrations of toxic heavy metals at two BGS sample sites of sediment soils deposited in a surface stream in close proximity to Ellesmere Port-1.

8.2 In view of the proximity of the development to seismically active faults and presence of porous superficial sediments plus exposure of the region’s most important aquifer, then the risk of the development disturbing the sediments containing high concentrations of toxic heavy metals is unusually high.

8.3 The sediment near Ellesmere Port-1 has by far the highest copper-tin anomaly (Cu+Sn) in the entire region (North Wales, Merseyside, Cheshire,
Greater Manchester and Lancashire), with copper being 288 & 270ppm, and tin being 137 & 73ppm. Lead (Pb) levels are also very high.

8.4 The BGS draws attention to the sediment soils of Ellesmere Port also having extraordinarily high levels of uranium (U 26.8 and 19.3 ppm) exceeded only by the levels of uranium (30 ppm) in stream sediments near the Springfields Nuclear Facility on the Fylde west of Preston. According to the BGS, the uranium anomaly at Ellesmere Port is coincident with high copper (Cu), molybdenum (Mo) and tin (Sn) and that this is anthropogenic contamination in stream sediment on a stream draining from the Capenhurst Nuclear Facility. I have traced the stream back to Capenhurst on high-scale plans. I have many concerns.

8.5 BGS sampled the two sites more than 20 years ago. My information is that the Capenhurst Nuclear Facility had, and apparently still has, a license to legally discharge small amounts of toxic heavy metals into the stream known as Rivacre Brook. It can therefore be reasonably assumed that the levels of uranium - and other more toxic elements - in the stream sediments have increased substantially since then, perhaps doubled.

8.6 Rivacre Brook is in a popular statutory Country Park and passes through a statutory Local Nature Reserve close to the Ellesmere Port-1. A risk to visitors and wildlife already exists, and may be increased significantly if the toxic sediments are disturbed by the development.

8.7 One of the UK's main reservoir rocks for groundwater underlies the stream sediments. The risk of the toxic heavy metals (U, Cu, Sn, Mo, Pb, Zn etc.) contaminating the groundwater is unknown but should be addressed before permission for any activities in Ellesmere Port-1 to be considered. Any disturbance to the groundwater may - or may not - risk mobilising toxic heavy metals entering the important sandstone aquifer, an event that is unlikely to be reversible. This is a real risk and there is no scientific evidence showing that the risk may not occur, and so a precautionary approach should be taken.
8.8 Likewise, I am concerned that one or more of the many faults in the Ellesmere Port area that cuts through the sandstone aquifer may be seismically active and thereby the risk of contaminating the sandstone aquifer by toxic heavy metals from the stream sediments may be significantly increased; again an event that cannot be reversed.

8.9 Regarding the sandstone aquifer, recent research shows that the vital groundwater for public supply in Merseyside is, to a significant degree, controlled by clearly defined faults on the Liverpool side of the Mersey Estuary, by the faults serving to compartmentalising the groundwater in this large aquifer.

8.10 Groundwater compartmentalisation by faults in Merseyside can be understood by reading the free on-line research paper: (E.A. Mohamed and R.H. Worden 2006)\(^3\). The same giant aquifer and many of the same faults extend across the estuary into the Stanlow, Ellesmere Port and Eastham area. However, insufficient is known about the orientation of faults under the estuary and therefore a cautionary approach is essential. **In other words, why risk permanent damage to the groundwater of one of our largest cities by acidification on the opposite side of the aquifer? A precautionary approach should be taken.**

8.11 The ground conditions of a large area immediately east of Ellesmere Port has recently been intensively investigated by the BGS (Footnote3). It demonstrates a multitude of ground issues, including the buried bedrock topography of Sherwood Sandstone beneath variable thickness of superficial deposits. This formed part of the research topic of my Masters Degree in geology. Reviewing the excellent BGS report, there seems enough evidence to postulate the EP-1 development may encourage migration of methane and H\(_2\)S up faults and along fault bounded compartments in the Sherwood Sandstone aquifer to be trapped below the

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superficial deposits, and in time creating fires and pollution at the surface. I am considering this possibility, and will report progress on January 1st.

8.12 Finally, as an environmental scientist I am concerned about EP-1 causing intensification of industrialisation of the area and therefore contribute to the piecemeal degradation of the international, national and local wildlife and recreational amenity of the upper reaches of the Mersey Estuary.
9. Conclusion

9.1 IGas have suggested that the proposed development is conventional gas exploration. This is not correct. The nature of the Pentre Chert and its geology means that testing EP-1 will amount to testing for unconventional gas.

9.2 There are a number of risks or impacts arising from the geology of the area which are relevant to whether permission should be granted for IGas’s application. Each of these risks are real and mean that a precautionary approach should be taken so that the testing cannot take place unless IGas can show, without scientific certainty that these risks will not materialise. They are:

9.2.1 The risk of sudden blowout of inflammable gas because of the faulting in the region and because IGas is incorrect about a pinch-out in the area.

9.2.2 Risk to air quality because of the presence of hydrogen sulphide.

9.2.3 Risk of seismic activity; and

9.2.4 Risk to the watercourse and to the aquifer.
APPENDIX 1


ALDC Working Draft of December 2018, for publication in January 2019, 35 pages et seq.

ABSTRACT

We present fresh insights into the stratigraphy, tectonic history and hydrocarbon resource potential of Mississippian (Lower Carboniferous) strata in the Bowland Megabasin of North-West England. The Megabasin contains exceptionally thick shales that are excellent both as source rocks for hydrocarbons, and as seals for trapping conventional oil and gas resources. The shales are interbedded with a wide range of potential reservoir rocks for holding conventional oil and gas, ranging from delta-top sands to sands of deep-water turbidite fans; from deep-water carbonate banks to shallow-water carbonate platforms. The potential attracted more than twenty exploration companies who took up blocks for conventional oil and gas prospects. In the event, only a handful of wells were drilled. The exploration companies eventually relinquished their exploration licenses, but released into the public domain a legacy of thousands of miles of seismic lines. Exploration companies interpreted the seismic lines and identified with some confidence the presence of thick beds of evaporites of Tournaisian age near the bottom of the Mississippian sequence in parts of the Bowland Megabasin. The evaporites are deemed to be predominately of anhydrite and possibly gypsum, although other evaporite minerals such as rock salt may be locally present. The possible presence of anhydrite at depth is the focus of the present report as it is the likely source of hydrogen sulphide emanating from more than 42 long-lived stinking springs that constitute the Bowland H₂S Province within a
large tract of the Bowland Megabasin. The consensus of the oil and gas industry is that copious amounts of H$_2$S can be generated by chemical reaction between methane and anhydrite. Accordingly we would expect large volumes of sulphate-rich groundwaters from the anhydrite would migrate laterally and vertically driven by compaction during burial, and due to the basin-wide transpressive-transtensional folding and faulting of the Ribblesdale Fold Belt. The sulphate-rich groundwaters would migrate again during the inversion of the Ribblesdale Fold Belt during Hercynian mountain-building, and yet again during the major phase of uplift, erosion and collapse of the proto-Iceland Hotspot in Tertiary times. Intimate contact at depth between large volumes of sulphate-rich groundwater with methane from the thick stack of unconventional gas resources would repeatedly generate amounts of hydrogen sulphide. Most of the H$_2$S would be rapidly ‘buffered’ by large amounts of iron present in most of the ferruginous organic-rich shales to produce pyritic (FeS$_2$) shales. Yet in a pyrrhic victory, some of the H$_2$S would relentlessly find pathways to the surface to feed more than forty stinking H$_2$S springs of the Bowland H$_2$S Province which are known to have been active for at least several hundred years. On a wider canvas, we note that all Mississippian basins with thick sequences of Tournaisian sediments between Birmingham and the Midland Valley of Scotland have thick evaporites near their base – notably anhydrite.

There is reason to expect thick beds of anhydrite to be present at depth beneath the Bowland Megabasin under much of North-West England, posing questions about the commercial viability of the nascent unconventional gas industry in the Fylde and Wirral.

We describe ‘lessons to be learned’ from unfiltered know-how from the USA regarding onshore drilling for sweet and sour gas. In particular we recommend adoption in North-West England of the setback distance adopted in 2013 by ordinance of the city
administration of Dallas in Texas, after a long process of detailed investigation and deliberation, for gas wells and gas storage facilities to a distance of 1,500 feet (around 457 metres) in view of the perceived risks to health, safety and environment of people and property. Know-how transfer from Dallas to North-West England of how this decision was arrived at would bring factual evidence to the ongoing debate in the UK. The State of Texas later overruled the city administration of Dallas for reasons of State.