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Appendix E

# Review of Roseacre Wood Environmental Statement and IPPC Application

Technical report

Health Impact Assessment support, shale gas exploration

Lancashire County Council

2nd September 2014

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## Abbreviations and acronyms

AQMA ..... Air Quality Management Area
BAT ..... Best Available Technology
BSOR ..... Borehole Sites & Operations Regulations
CAPs ..... Climate-Altering Pollutants
$CO_2$ ..... Carbon Dioxide
COMAH ..... Control of Major Accident Hazards
COMEAP ..... The Committee on the Medical Effects of Air Pollutants
DCLG ..... Department of Communities and Local Government
DECC ..... Department of Energy and Climate Change
DEFRA ..... Department for Environment, Food & Rural Affairs
DETR ..... Department of the Environment Transport and the Regions
DH ..... Department of Health
DPH ..... Director of Public Health
DSEAR ..... Dangerous Substances and Explosive Atmospheres Regulations
DsPH ..... Directors of Public Health
EA ..... Environment Agency
EIA ..... Environmental Impact Assessment
EMMP ..... Environmental Management and Monitoring Plan
ES ..... Environmental Statement
GHG ..... Green House Gas
HGV ..... Heavy Goods Vehicle
HIA ..... Health Impact Assessment
HPA ..... Health Protection Agency (part of Public Health England from 1st April 2013)
HSE ..... Health and Safety Executive
HSSE ..... Health Safety, Security and Environment
ICRP ..... International Commission on Radiological Protection
IRR99 ..... Ionising Radiations Regulations 1999
LCC ..... Lancashire County Council
LEP ..... Local Enterprise Partnership
LFL ..... Lower Flammable Limit
LLWR ..... Low level Waste Repository
LTOBM ..... Low Toxicity Oil Based Muds
MSDS ..... Material Safety Data Sheet
NICE ..... National Institute of Health and Care Excellence
NORM ..... Naturally Occurring Radioactive Materials
NOx ..... Oxides of Nitrogen (NO & $NO_2$)
NPPF ..... National Planning Policy Framework
PAH ..... Polycyclic Aromatic Hydrocarbons
PHE ..... Public Health England
PM ..... Particulate Matter (e.g. $PM_{10}$ & $PM_{2.5}$)
QRA ..... Quantitative Risk Assessment
REVIHAAP ..... Review of evidence on health aspects of air pollution
UU ..... United Utilities Plc
VOC ..... volatile organic compounds
WHO ..... World Health Organization

# 1 Executive Summary

1.1.1 This is an independent report prepared by Ben Cave Associates Ltd for Lancashire County Council (LCC) to support work on defining the requirements for Health Impact Assessment (HIA) of temporary shale gas exploration at a site known as Roseacre Wood Lancashire by Cuadrilla Elswick Ltd. A planning application has been submitted for exploration (1). The application is accompanied by an Environmental Statement (ES) (2). There is a separate planning application (not reviewed by this report) that addresses the installation of seismic monitoring infrastructure (3).

1.1.2 We have reviewed the application's ES (2) and the appropriate appendices with special reference to health and wellbeing. The ES, the report which is produced to support the Environmental Impact Assessment (EIA), is a useful source of information for the HIA. Many of the factors considered in the EIA will have an effect on health and wellbeing. However, human health is not a core topic for EIA. The difference in perspective and methodologies between EIA and HIA means that there are inevitably issues addressed in the EIA that can be expanded upon in a HIA.

1.1.3 The EIA is an official document provided to support a planning application. It needs to demonstrate how a potential project will be implemented without having an adverse effect on the environment, and how operational activities can be expected to meet legal requirements. In the main, the data used is pertinent to the immediate locality. An HIA is not constrained in this way, and will offer comments upon impacts on health at a distance in space and time, and in the light of emerging knowledge. A project may be projected to operate within existing limits, but science is ahead of regulation. HIA thus offers comment on evidence for actual health impacts rather than regulatory or statutory requirements.

1.1.4 We note that the seismic array is subject to a separate planning application (3). Some information regarding the seismic array has been provided within the body of the Roseacre Wood ES (2) and has therefore been considered. Based on this information, it does not appear likely that there will be measurable changes in public health outcomes arising from the installation of the seismic array but this would need to be confirmed if further HIA work were to take place.

1.1.5 The review identifies two main issues.

- The conclusions of the ES are based upon appropriate management of risk and enforcement of regulations and guidelines. Whilst it is generally acknowledged that the regulatory regime overseeing and enforcing safety standards for the emerging fracking industry should provide appropriate protection to the public and workforce (4), commentators have expressed doubt that current regulation is fit for purpose (5).
- The ES defers a number of issues until after the application has been determined: for example, it is unclear from the ES when the Environmental Management and Monitoring Plan (EMMP), which details the monitoring scope and reporting procedures, will be available; and it is unclear from the ES whether a quantitative risk assessment (QRA) has been, or will be, undertaken to determine the risks and responses required in the event of an unplanned emergency scenario. Whilst the ES may reasonably defer these issues to post application stages, the absence of these documents hinders the fuller consideration of potential health effects associated with the application.

1.1.6 On the basis of this review we find that the ES has been completed to fulfil the requirements of an EIA, as would be anticipated. As noted above we also find that it leaves much to the post application documentation and regulatory framework. We identify some

technical clarifications that could be sought by the Director of Public Health for LCC in exercising that role's duty to 'assure' health protection for the area. These clarifications are summarised in the conclusion of this report.

1.1.7 The ES finds no significant adverse health impacts for people living and working close to, or at, the site. HIA uses different thresholds and thus might reach different conclusions. The potential adverse impacts are generally greatest at the residential properties closest to the site. The overall burden for these residences is not currently known.

1.1.8 The ES and commentators place great weight on regulation. The regulators and PHE report that an appropriate regulatory framework is in place. We note that currently the regulatory framework is untested in the UK and in other countries regulation has not prevented adverse health effects: detailed monitoring and additional studies therefore have great merit.

1.1.9 Until regulatory responsibilities and expectations have been more clearly described it may be difficult for the Director of Public Health for LCC to discharge the duty of assurance with regard to health protection. Furthermore, until post application documentation, such as the QRA and EMMP, have been produced, it may be difficult to rule out the potential for health impacts to occur.

# 2 Introduction

2.1.1 This report supports work by Lancashire County Council (LCC) on defining the requirements for Health Impact Assessment (HIA) of exploratory shale gas operations in Lancashire.

2.1.2 This is an independent report prepared by Ben Cave Associates Ltd for LCC.

2.1.3 The purpose of the report is to examine the links between health and wellbeing and the potential effects (beneficial and adverse) of exploring for shale gas.

2.1.4 Further information about the study are presented in documents which accompany, and need to be read in conjunction with, this report:

- Overview report (6);
- Review of Preston New Road Environmental Statement (7);
- Community Engagement Report (8); and
- Annexe to Overview Report (9).

2.1.5 The review uses the WHO definition of health as a 'state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity' (10).

## 2.2 Approach and Methods

2.2.1 This review forms part of HIA work undertaken by LCC. The Applicant has not taken part in this review. This separation from the Applicant underscores the independence of the HIA team from the Applicant. However, it also reduces the opportunity to influence the design and implementation of the Project prior to publication of the HIA findings.

2.2.2 HIA is usually iterative and allows for the modification of the Project or additional modelling to rule out significant health effects prior to the final report being issued. In this case the HIA process flags up potential issues requiring further investigation. This minimises the opportunity for interventions to address potential health effects. As a consequence this report leaves some issues unresolved. Some of the clarifications raised by this review relate to the permitting, regulatory and monitoring framework that is being developed in parallel. For Roseacre Wood the permitting application has been commented upon as part of this review.

2.2.3 Two people reviewed the ES to ensure coverage of all relevant sections. The ES is long and it is detailed. Thus, we reviewed each chapter of the ES at a high level. The cultural heritage and ecology chapters were excluded from the review as they were judged to have less relevance to health receptors, though it is observed that adverse impacts on cultural heritage, should they occur, can have an adverse effect on wellbeing. The following chapters were subjected to more detailed review:

- air quality;
- noise;
- public health;
- hydrogeology and ground gas;
- water resources;
- resources and waste; and
- transport.

2.2.4 Other ES technical chapters and the initial scoping document were reviewed at a higher level.

2.2.5 This review has been from the health perspective only. It is not exhaustive but includes sufficient detail to reach general conclusions on: the adequacy of the EIA to inform specific clarifications; reassurances that could be sought by the Director of Public Health for LCC, in respect of the anticipated activities; and long term monitoring to underpin the veracity of those assurances.

2.2.6 The review is one stage in evaluating the impacts which may accrue as a result of the proposed project. This undertaking can be used to support any part of an HIA which seeks to inform the Roseacre Wood application with regard to potential health effects (1).

2.2.7 The review commentary is primarily based on professional judgement with reference to relevant literature where appropriate.

2.2.8 The review's remit is listed below.

- Note the issues, relevant to health that have been covered, comment on the results and examine the assumptions that have informed the analysis.
- Examine details of the methodologies used by the Applicant's consultants and the receptors identified and provide commentary on the thresholds used from a health perspective.
- Identify specific areas for further HIA investigation.
- Establish how the existing ES data could inform specific HIA issues and the next steps for linking this data to the health literature and health assessment.
- Produce a list of detailed issues that require further clarification with the ES consultants.

2.2.9 The ES notes that it provides a great deal of information about the application: this is due to its status as one of the first onshore deep gas shale exploration sites in England that is subject to an EIA (2).

*Consequently the level of detail within the baseline data and the assessment of likely significant effects are greater than that which might typically be produced for a temporary hydrocarbon exploration project. As the exploration (and potential production) of deep shale gas reserves progresses, and the Strategic Environmental Assessment (11) of future onshore oil and gas licensing is completed (and new guidance is published), the scope of future EIAs is likely to be refined and the volume of information contained in the ES may be reduced.*

2.2.10 This review does not seek to reach findings on significance or probability. Descriptive colloquial terms are used in relation to professional judgements reached by the reviewers. Such terms include: 'appropriate', 'adequate' and 'reasonable'. These terms are used to express that an action or process has been undertaken to a level that is considered acceptable and in line with good practice.

2.2.11 Reference to significance is specific to the methodology adopted by the ES chapter being reported. The term does not indicate that a level of statistical probability has been achieved ('p' or 'r' value). Furthermore, the term significant within an EIA is a reflection of the process findings against a set of criteria, as opposed to an opinion on the part of the authors of the ES. We have, therefore, sought to avoid using such terminology except where we have also used external criteria.

# 3 Review of the Roseacre Wood application for shale gas exploration

3.1.1 This section sets out results of a review of the documentation submitted to LCC by Cuadrilla Elswick Ltd for temporary shale gas exploration at a site known as Roseacre Wood, Lancashire (2). The review makes comment upon the ability of any element of the Project to have an impact on health, whether direct or indirect, short term, medium or long term, in near or far geographical perspective. The scope of HIA work is not limited to meeting statutory or regulatory limits.

## 3.2 General

3.2.1 This is a detailed ES for the level of proposed development. Overall the ES appears to have been completed to a standard which meets the requirements of an EIA. The issues raised in this review largely relate to requests for clarification. The ES provides a useful source of information to inform the HIA. Additional information from the permitting application technical documentation provides further assistance.

3.2.2 The proposed development is described in chapter 4 of the ES (2). The ES then examines the different aspects of this proposed development.

3.2.3 The ES notes Department of Communities and Local Government (DCLG) planning practice guidance for onshore oil and gas (12), which states:

*Individual applications for the exploratory phase should be considered on their own merits. They should not take account of hypothetical future activities for which consent has not yet been sought, since the further appraisal and production phases will be the subject of separate planning applications and assessments.*

3.2.4 We accept that the focus should rightly be on the current application (1). However it is also noted that the current application will have a direct bearing on any future applications for full-scale gas production on the site. Decisions taken as part of this application have the potential to influence the scope of such future applications. Care should be exercised in extrapolating conclusions about temporary, small-scale exploratory procedures to longer-term and larger operations.

3.2.5 The ES notes that, in the scoping opinion received from LCC on 11th March 2014, Public Health England requested a section in the ES that provides signposts to all the sections of the ES where potential health impacts have been assessed. The ES responds to this request in Chapter 20 *Public Health* and by supporting information within *Appendix T*. Public Health is not included in the ES non-technical summary.

3.2.6 The ES has scoped out the following topics:

- electromagnetic interference;
- microclimate; and
- site monitoring and management (as monitoring proposals are set out, where relevant, within the technical chapters of the ES).

3.2.7 The decision to scope out electromagnetic interference carries an addendum. There are several possible access routes to the proposed site. The preferred, but as yet unconfirmed, option is to create an access road through the adjacent MoD listening site at Inskip. This site has many overhead cables. These may need to be reconfigured in order to enable access of the heavy plant equipment in the development stages of the Roseacre wood site. There is no further information available regarding the electrical properties of these cables.

It is unclear if these are standard power lines or a higher rated system associated with the MoD site's function. If high non-standard current or voltages are being used, consideration should be given both to electrical arcing causing electrocution and EMF occupational exposures. It is presumed that this is subject to MoD disclosure. We suggest that the Director of Public Health for LCC should seek reassurance that any use of or changes to the MoD Inskip site is not associated with public or occupational increased risks from electrocution or EMF exposure.

3.2.8 Scoping out microclimate appears reasonable.

3.2.9 With regard to monitoring, the ES notes that the specific details will be developed following the planning determination. The coverage of monitoring in the ES chapters is variable. For example there is good discussion of monitoring for hydrogeology, but not air quality. Appendix E of the ES sets out introductory Environmental Management Plan information. It will be important to ensure that the monitoring strategy includes mechanisms to confirm that impacts are as expected by the ES.

3.2.10 These findings suggested the need for further information on the monitoring requirements needed to confirm the findings of, and the assumptions within, each chapter of the ES. This is important given that the Environmental Management and Monitoring Plan (EMMP) is not likely to be available before the application is determined. For example monitoring of flare emissions during the initial flow testing to measure radon and other hazardous/radioactive pollutant concentrations and dispersion.

3.2.11 Long term monitoring of the impacts from the project, should it be granted permission to go ahead, will be important. There are no clear lines of responsibility to ensure that gradual decline of the state of the fabric of the well over time can be monitored to ensure that gas leaks into the rock strata, atmosphere and groundwater are prevented. It is noted that the various government departments which each play a role in the regulatory process for this application are prone to change within government reorganisations. It is important that such changes in the future do not lose sight of long term responsibilities for such projects. We suggest that the Director of Public Health for LCC should seek clarity on the roles and responsibilities of the organisations that will oversee the long-term management of the wells post decommissioning to ensure that public health is not adversely affected at some point in the future. Long term needs to be defined. Given the length of time over which well degradation may occur a period of 100 years may not be unreasonable. We suggest that an appropriate timescale for monitoring should be identified in a literature review.

3.2.12 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC should clarify that the monitoring framework requirements set through the planning and permitting processes will address not only the short-to-medium term impacts of disturbance and pollutants arising from the site to the local population, but also the potential for long-term (and potentially more widespread) legacy impacts on groundwater and ground gas. Such monitoring should be tied to an action plan with defined roles and responsibilities for notifying and responding to exceedances for the full period of the monitoring. We suggest that the Director of Public Health for LCC should remain engaged with the process and information that emerges on monitoring from the planning and permitting processes.

3.2.13 Repeated reference is made, in the ES, to an absence of plausible pollutant pathways[1] in scoping and assessment decisions (e.g. for contamination of surrounding agricultural land). This approach gives strong weight to engineering solutions and failsafe technology or processes. Whilst we acknowledge that progress has been made in identifying lower risk sites to drill and developing engineering solutions, we also caution that no process is immune to failure. It is noted that the application will be supported by separate management plans. Regardless of their quality, many accidents occur as a result of humans choosing to ignore elements of management requirements.

3.2.14 The ES findings that effects are not significant, or not of concern to the Applicant, rely in the main part on the operator adhering to management plans, and operational controls.

3.2.15 We suggest that the Director of Public Health for LCC requests that regulators collectively produce a document that summarises the application's adherence to the DECC Regulatory road map guidance (13); including the planning and permitting conditions and monitoring requirements that have been imposed at each step for the protection of public health.

3.2.16 The ES states that the development does not fall within COMAH Regulations or the Major Accident Off-Site Emergency Plan (Management of Waste from Extractive Industries) (England and Wales) Regulations 2009. However this review judges that consideration should be given to unplanned emergency event scenarios, including the impact on local population, health resources and occupational workforce. The boundary of the zone of acceptable risk, or similar, should be identified for any fire, asphyxiation or explosion risk due to loss of gas containment. An appropriate threshold to use to define this boundary may be half the lower flammable limit of the dispersed gas from the source (½LFL) (14). Consideration could also be given to other toxicity levels in any gas cloud, e.g. radon. This is particularly pertinent given the approach road which will service the project is narrow with tight bends. Such characteristics do not lend themselves to rapid response should this be necessary, either for the workers on site, or the local population.

3.2.17 Reference is made in the ES to site specific emergency response plans to enable rapid and appropriate response to unplanned events in coordination with local emergency services where necessary. It is unclear if these have yet been produced. If available, the Director of Public Health for LCC should review these documents.

3.2.18 These findings suggested the need for further information on

- A) site specific emergency response plans; and
- B) quantitative risk assessment (including unplanned events and reference to ½LFL thresholds).

3.2.19 It is noted that the Borehole Sites & Operations Regulations 1995 (BSOR) (15) as well as most provisions of the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) (16) apply to onshore well sites (17). These regulations require the production of a fire protection plan and plan for detection and control of toxic gases. Hazardous zones in the event of an unplanned release of fluids from the well must also be identified. This information does not appear to be currently available, so the risks to the public cannot be determined.

3.2.20 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC does not need to seek further specific clarification on A) site specific

[1] A plausible pollution linkage occur where there is a source, pathway and receptor.

emergency response plans but should remain engaged with the process and information that emerges on these issues from the emergency planning and permitting processes.[2]

3.2.21 With regard to B) quantitative risk assessment (including unplanned events and reference to ½LFL thresholds) we suggest that the Director of Public Health for LCC does seek further specific clarification to confirm that no members of the public would normally live, work, travel or pursue leisure activities within the zone of ½LFL[3] for worst case loss of gas containment.

## 3.3 Public Health

3.3.1 ES chapter 20 considers public health impacts of the Project. It evaluates several different health parameters, including those of risk perception on health, and takes into account questions which have been raised by Public Health England.

3.3.2 This review notes that there are wider regional and national public health benefits from increased energy security. These are linked to many determinants of health, including thermal control in homes and power for health and employment services. These wider benefits must be weighed against the adverse disturbance, nuisance, anxiety and contamination impacts that may affect the local population.

3.3.3 For each parameter: noise; air quality; water; perception; community and facilities; and physical activity general conclusions on the part of the Applicant are that the Project will not have a significant effect on human health.

3.3.4 The exception to this is with the terminology deployed with regard to noise. The Applicant states in ES section 20.5.1 paragraph 22 that 'There is no evidence to suggest that the type and level of exposure likely to result from the project may be linked to cardiovascular effects or cognitive impairment.' The health impacts of noise from the Project are considered further within a separate section of this review (see section 3.5) based upon the evidence provided within ES chapter 16 and appendix P.

3.3.5 Other potential health effects are similarly addressed within subsequent chapters of this report, referencing the technical appendices as well as the ES, scoping document, and other supporting material as appropriate.

3.3.6 The ES states that following a review of the proposals and the receptors present in the vicinity of the scheme, it has been concluded that there is no potential for health and wellbeing impacts to arise on:

- effects on community facilities and social networks; or
- physical activity.

3.3.7 Justification for this (20.4 para 19) is that there will not be a large influx of workforce which may compromise access to existing infrastructure, and that the 'small scale and temporary nature of the project' will not impair people's ability to access a healthy lifestyle in the way that is currently the case.

3.3.8 It is noted that there are several rights of way in the vicinity of the proposed Project. Although it is acknowledged that these are not networked, this does not reduce their attractiveness for recreational use, for activities such as short walks. Similarly, the current state of low use of the roads with regards to traffic may mean that they are used as a path network in their own right. The introduction of heavy vehicles into this environment is

[2] We note that Emergency Planning is an issue that was raised in the Community Engagement workshop (8).

[3] Being outside the area where gas has dispersed from the source to a concentration of half its lower flammable limit (½LFL) is a recognised threshold of reasonable safety (14).

likely to have an impact on people's willingness to use them. For some residents this loss of tranquillity and ability to meet neighbours may have a direct impact on their mental and physical health. This is a rural area into which it is intended to impose an industrial activity. Its impact at this location may well be received differently from a different geographical and community base.

3.3.9 The ES identifies and responds to a PHE publication on shale gas extraction (4). The ES explains how it responds to the PHE recommendation in that report, including some consideration of broader public health and socio-economic impacts. The PHE publication focuses on the potential health impacts of exposures to chemical and radiological pollutants. The PHE document states that it does not include consideration of the following issues:

- climate change;
- greenhouse gas emissions;
- sustainable use of water resources;
- nuisance issues such as noise and odours;
- traffic (apart from vehicle exhaust emissions);
- occupational health;
- visual impact; or
- socio-economic benefits or impacts of shale gas extraction.

3.3.10 These issues are considered within the ES but they are not all identified by the Applicant as being relevant to health as some of the appropriate connections have not been made. Not all signposting provided in ES Appendix T (analysis) gets addressed in the ES Public Health chapter.

3.3.11 It is worth commenting that although the ES Public Health chapter is intended to consider the effect on the community, as opposed to individuals, there are some communities which we would expect to experience effects which become cumulative and synergistic: noise, dust, light, inconvenience. Defining an effect of 36 months duration as transient may be justifiable when looked at over the duration of the project. We would not expect 36 months to be a transient event for people living close to the Project, especially if they are elderly. The uncertainty of the outcome (*i.e.* the possibility of more drilling and further applications) or possible pollution episodes can lead to anxiety with attendant health problems.

3.3.12 The Public Health chapter (chapter 20) of the ES discusses the following issues and concludes there are no significant impacts from:

- noise;
- air quality;
- water (surface and groundwater); and
- perception effects.

3.3.13 In reaching this decision reference is made to impacts being below relevant legally imposable limits and standards, however these are not explicitly listed in the Public Health chapter. HIA can consider a wider range of issues than those summarised in the ES Public Health chapter. Furthermore, whilst many individual residual effects may be classified as not being significant, there are a small number of homes which are impacted by several issues. The overall burden for these residences is not currently known.

3.3.14 Noise, air quality and water are all topics with ES chapters in their own right. We review these separately by individual topic chapters to obtain a clearer understanding of how the findings were reached. The following section considers what, in the ES are called, perception effects.

## Perception effects

3.3.15 Perception effects are covered in Public Health chapter 20. No formal methodology is set out for the consideration of perceptions of risk. We note that the term 'perception' can be considered pejorative and infer that something is not real. We also note that this term is used within the literature on shale gas extraction (see for example, Ladd (18)). In any further shale gas extraction HIAs we would advise framing this as an investigation of *community understanding of risk*.

3.3.16 The discussion of perceptions makes limited reference to supporting literature, relying largely on a review of case studies looking into health risk perception in the North West of England (19). Whilst this is a useful source, particularly due to its geographic relevance, on its own it does not constitute a full picture of the issues. We suggest in the following paragraph some recent studies that would bear further examination.

3.3.17 Although a wide conceptual base to the consideration of perception risks is not essential for the ES, the following issues raised in the health literature could be the subject of further consideration in the context of the setting of the project:

- There are significant differences in community responses to similar public health threats. Distinguishing factors may include: prior experience and visibility of threat; socio-demographic characteristics; volume and type of media coverage; or government reaction and availability of social support (20).
- Risk-refuting information may reduce anxiety about a particular disaster, but may not reduce anxiety about an industry in general (21).
- Risk communication strategies that incorporate the needs of the target audience(s) with a multi-faceted delivery method are most effective at reaching the audience. Furthermore, the response to risk communications may be influenced by: personal risk perception; previous personal experience with risk; sources of information; and trust in those sources (22). It is worth noting that this is a community which is sensitised, having recollection of the Abbeysteads incident thirty years ago, in which migration of methane was responsible for an explosion.
- Evidence from the nuclear industry suggests that people with a high perception of risks may be less attentive to information about protective actions. People with little confidence in authorities may also be more likely to have a low reception of information (23).

3.3.18 If someone deems that they are at risk (irrespective of the level of risk) this can affect their health and well-being. For example: increased levels of fear, anxiety and stress affect mental well-being, which can also cause physiological changes including increases in adrenaline, nor-adrenaline and cortisol levels; increased levels of fear/anxiety can lead to social isolation especially in older people who may be afraid to go out, and thereby experience reduced social contact (and possibly reduced levels of social support), which can lead to depression (pre-existing health states that exacerbate this effect include hearing loss, which in combination with depression is linked to the development of Alzheimer's). Women who are pregnant or who have young children may also choose not to go out through fear, and thereby experience similar effects, coupled with a reduction in physical activity for the women and the children.

3.3.19 With regard to risk perception, the Applicant has outlined ways in which provision of information will be expected to allay fears. Participants in the Community Engagement workshop (see source 8) suggest this is an important health issue. No evidence is presented that information provided by the Applicant to date has reduced community fears about the project.

3.3.20 The ES discussion includes a summary of concerns raised during an ES consultation with residents. It is noted that consultations have been general, covering a Project for development known as Preston New Road, as well as this current application for Roseacre Wood. However, the issues of concern tend to be generic, and include perceptions of risk from:

- radioactive material;
- flammable gases;
- potentially hazardous materials on site;
- emissions to air (including flaring);
- induced seismicity; and
- ground / surface water pollution.

3.3.21 The issue of risks to potentially sensitive groups or individuals (e.g. children or people with pre-existing health conditions) was also raised. Although information on many of these issues is provided elsewhere in the ES, the Public Health chapter does not clearly signpost or summarise the actual risks presented by the current application for these concerns. We note that the Applicant's response to their public consultation has addressed these issues directly, and in some cases they have undertaken to make alterations accordingly.

3.3.22 These findings suggested the need for further information on the influence of people's understanding of safety on the surrounding areas, including consideration of: property values; amenity value of outdoor space; and levels of physical activity.

3.3.23 Based on this review's findings and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC does seek further specific clarification on the influence of people's understanding of safety on the surrounding areas, including consideration of: property values; amenity value of outdoor space; and levels of physical activity. This is because these are potentially important determinants of health that are currently not well understood.

## 3.4 Air quality

3.4.1 ES chapter 6 assesses the air quality impact of the Project, with supporting information in Appendix F. It explains that data about the Project activities (e.g. the type and number of vehicle movements and the quantity and quality of gas burned in the flares) were used to predict the quantity and distribution of gas and dust emissions. The chapter states that these were then compared to legal levels that set out safe limits for these emissions. This assessment also assessed the potential quantities of radioactive gas, specifically radon, that could be emitted during flaring. The chapter concludes that none of the predicted emissions exceed safe limits. It therefore concludes that the Project will not result in a significant effect on air quality.

3.4.2 The ES chapter 6 air quality notes that the area in which the site is situated is rural and not densely populated. There are no existing significant sources of emissions to the atmosphere. Likewise, there are no areas within the vicinity of the Site where there is an existing problem with air quality or pollution. This appears consistent with viewing the site using Google earth (24), Defra AQMA mapping (25) and Environmental Agency interactive mapping of emissions permits and incidents (26), as well as a site visit.

3.4.3 There are farm buildings in close proximity to the north of the proposed development (the closes residential building appears to be a farmhouse approximately 260m to the north of the site surface boundary shown in ES figure 4.3); a further residential property is

approximately 300m distant to the south east of the site surface boundary. Other residential properties in Roseacre are approximately 320m – 500m distant.

3.4.4 The ES assesses five sources of air pollution – these are emissions from:

- construction activities;
- the vehicles associated with the use of the Site;
- the flaring of gas during flow testing;
- equipment associated with the operation of the Site (e.g. generators, pumps and blenders); and
- fugitive emissions.

3.4.5 The assessment concludes that the main atmospheric pollutants from the Project are the gases that are emitted when gas is burnt in the flare. Modelling of NOx emissions (section 6.7.5.3, and appendix F) indicate that there are several exceedances of NOx guideline values, as laid down by EA (based on WHO values). However, the Applicant states that when background levels are taken into account and adjustments made for process emissions contribution, (the recommended method found in Environment Agency H1 Guidelines for emission modelling) two locations still have a minor impact. There is no identification of these receptors.

3.4.6 The Applicant has used ADMS to model air impacts. As these have been modelled, it would have been reasonable to see the modelled data included in either the ES or the appendix, showing the absolute values, as well as the modelled PEC. This has not been included.

3.4.7 Similarly, the Applicant has referred to dispersion of benzene, and radon, as emissions of products of combustion, or incomplete combustion. In each case the model has not been shown. It is therefore difficult to make meaningful comment on the impact on local receptors. It is noted that impacts to ecological receptors have been closed out; human receptors have not.

3.4.8 It is not clear whether or not two flares will run simultaneously. In some areas of the ES it seems that this is a possibility, in others, only one appears to be accounted for. The Director of Public health should seek clarification as to the number of flares which may be operational at any given time; the modelling of the impact from both of those flares if two is the given number, and the emissions of radon, NOx and benzene for those two cumulative outputs.

3.4.9 Section 6.2 paragraph 3 of the ES identifies several sources of fugitive emissions, from equipment, and plant (flare). However, there is also an assertion (section 6.4.5 para 52) that there is no intention to have fugitive emissions. Clearly this would be the case: fugitive emissions are indicative of loss of control to a greater or lesser degree. Worst case scenarios for this could be calculated and assessed.

3.4.10 These findings suggested the need for further information on the distance between a potential source of fugitive gas releases and residential properties.

3.4.11 We suggest that the Director of Public Health for LCC seeks further specific clarification on the risk from worst case fugitive emissions including quantitative risk assessment.

3.4.12 It is unclear if dust will be a feature of the early stages of drilling. It is likely that wet drilling (using drilling muds as described in ES section 4.7.4.) will take place; however, this has not been stated. It is therefore important to ensure that dust and smaller particulates will not be released during the drilling process. If they will be, they need to be included in any calculation of potential impact. This point applies to both drilling sites (RW and PNR).

3.4.13 The Air Quality Standards Regulations 2010 sets out target and limit values for England (27). The UK Air Quality Strategy sets out air quality objectives and policy options to improve air quality in the UK (28). The ES air quality assessment uses these air quality limit values to assess the significance of impacts. Whilst this is a reasonable methodology to adopt, it is noted that:

- the recent REVIHAAP report by the World Health Organization (29) into the health effects of air pollution may result in further lowering of statutory thresholds and WHO recommended levels for air pollutants; and
- the European Commission has tabled a proposal for The Clean Air Policy Package, which would update the 2008 directive with revised limit and target values (30).

3.4.14 Although it is accepted that the application should be compliant with current, not hypothetical future regulatory and statutory requirements, consideration of relevant scientific evidence on thresholds of harm is an important consideration for HIA. For example the REVIHAAP report confirms that for Particulate Matter there is no evidence of a safe level of exposure or a threshold below which no adverse health effects occur (29). The Committee on the Medical Effects of Air Pollutants (COMEAP)'s report on particulate air pollution concluded that in quantitative terms a pollution reduction of 1 $\mu g/m^3$ of $PM_{2.5}$ would lead to on average 20 days increased life expectancy from birth per person (the extent to which individuals are affected is likely to be highly variable) (31).

3.4.15 According to the Air Quality Standards Regulations 2010, $PM_{2.5}$ annual mean limit values of 25$\mu g/m^3$ is to be met by 1st January 2015 (27). The ES does not discuss the project's impact on levels of $PM_{2.5}$. Sources of $PM_{2.5}$ include diesel generators, vehicles (both dust from movement and exhaust emissions) and flaring. Such impacts should be treated as cumulative. This type of impact also has the potential for differential impacts particularly for people with a pre-existing respiratory conditions or children whose bodies are still developing (some of whom may also have pre-existing health conditions).

3.4.16 These findings suggested the need for further modelling from the Applicant which takes into account the cumulative output of $PM_{10}$ and $PM_{2.5}$ for flaring, traffic movement, construction, generators, and other activity. We recognise that $PM_{2.5}$ is not usually included in ESs but it is an important issue for health (32).

3.4.17 A clear course of action on this issue is difficult to determine as a judgement must be reached on proportionality versus potential health impacts where there is no known lower threshold for harm. Based on the precautionary principle we suggest that the Director of Public Health for LCC confirms with the Applicant that $PM_{10}$ and $PM_{2.5}$ levels are as low as reasonably practical using BAT. A planning condition covering all types of emissions and pollutants to this effect could be considered.

3.4.18 The demonstration that all pollution will be as low as reasonably practical using BAT is wider than just PM or even air quality and should also include other forms of disturbance, such as noise and light (see later sections).

3.4.19 As an alternative to statutory and regulatory targets any exceedance of the air quality thresholds set out by the World Health Organization (33) could be considered a significant negative impact. Although these more stringent thresholds are sometimes viewed as aspirational, particularly in areas with high background air pollution, they could be a more appropriate set of values for HIA. As noted above some of these values may be further reduced as a result of the REVIHAAP report (29).

3.4.20 Table 3-1 provides a comparison, for those thresholds which have directly comparable units, between the UK Air Quality Standards Regulations 2010 (27) and those of the WHO (33). The differences relate primarily to particulate matter and sulphur dioxide

concentrations. Sulphur dioxide is not expected to be produced; the Applicant states that the composition of the gas, based on the gas produced at two other (local) sites, is expected to be low in sulphur. This will need to be verified if and when flaring commences.

Table 3-1: Comparison of UK Air Quality Standards and WHO Guide Values

| Pollutant | UK Air Quality Standards | WHO Guide Values |
|---|---|---|
| **Particles ($PM_{10}$)** | 50 µg/$m^3$ 24 hour mean | 50 µg/$m^3$ 24 hour mean |
| | 40 µg/$m^3$ annual mean | 20 µg/$m^3$ annual mean |
| **Particles ($PM_{2.5}$)** | 25 µg/$m^3$ annual mean | 10 µg/$m^3$ annual mean |
| **Nitrogen dioxide** | 200 µg/$m^3$ 1 hour mean | 200 µg/$m^3$ 1 hour mean |
| | 40 µg/$m^3$ annual mean | 40 µg/$m^3$ annual mean |
| **Ozone** | 100 µg/$m^3$ 8 hour mean | 100 µg/$m^3$ 8 hour mean |
| **Sulphur dioxide** | 125 µg/$m^3$ 24 hour mean | 20 µg/$m^3$ 24 hour mean |

3.4.21 Exhaust emissions are an important source of traffic-related pollution, and epidemiological and toxicological studies have linked such emissions to adverse effects on health (29). It is also noted that road abrasion, tyre wear and brake wear are non-exhaust traffic emissions that become relatively more important with progressive reductions in exhaust emissions, and to which the Applicant's vehicles will contribute. Toxicological research increasingly indicates that such non-exhaust pollutants could be responsible for some of the observed adverse effects on health (29).

3.4.22 The ES air quality chapter does not indicate clearly the expected composition of the gas to be extracted. It does suggest that volatile organic compounds (VOC) are not likely to be present. It is not clear if levels of other gases such as ozone (indirect impact resulting from the emission of NOx with sunlight, and which may be high at a location which is influenced by maritime incursions of ozone) or polycyclic aromatic hydrocarbons (PAHs) should be considered. Note the substances listed by Kovats et al (34) as being potentially present. Such data on expected concentrations could be reviewed against applicable standard or guideline value, including reference where appropriate to the HPA Chemicals & Poisons A-Z and compendium to comment on expected toxicity levels for fugitive gas releases. Concentrations in extracted gas would be needed in appropriate unit (e.g. mg/$m^3$ or ppm) to aid comparison with thresholds for health impacts.

3.4.23 These findings suggested the need for: further information on the predicted composition of the gas that will be extracted; how the composition of the extracted gas will be verified and monitored; and what remodelling will be undertaken once this information is available.

3.4.24 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC does not need to seek further specific clarification on this point, but should remain engaged with the process and information on composition and monitoring of flare emissions that emerges from the planning and permitting processes.

### *Radon*

3.4.25 As radon emissions are not a standard inclusion within EIA air quality assessments, this review has gone into greater detail on this specific issue. Radon is an issue for both air quality and water quality associated with the application. The air quality impacts are discussed here. Water quality impacts of radon are discussed in the review of the ES hydrogeology chapter.

3.4.26 An important consideration in this case is that unlike the natural migration of ground radon into homes, this potential radon exposure arises from a conscious decision to undertake an activity that increases the radon concentration in the local atmosphere. Whilst the levels are likely to be below statutory or regulatory maximum values (based on the ES modelling results), the radon levels do present a potential health impact, as there is no known threshold below which radon exposure carries no risk (35).

3.4.27 Radon comes from uranium which occurs naturally in many rocks and soils. Most radon gas breathed in is immediately exhaled and presents little radiological hazard. However, the decay products of radon attach to atmospheric dust and water droplets which can then be breathed in and become lodged in the lungs and airways. Some radon decay products emit alpha particles which cause significant damage to cells in the lung. Radon is now recognised to be the second largest cause of lung cancer in the UK after smoking (36).

3.4.28 For Radon, the ES adopts the International Commission on Radiological Protection (ICRP) dose constraint of 300 microsievert (μSv) per year for a single source.[4]

3.4.29 Mobbs et al place this threshold in perspective (37): epidemiologists, radiobiologists and medical practitioners may consider a few tens of millisievert (mSv) to be a low radiation dose. National radiological protection standards are specified in the Ionising Radiations Regulations[5], with annual dose limits of 20 mSv for workers and 1 mSv for members of the public. Public radiological protection standards for radioactive discharges are set at a dose constraint of 0.3 mSv (i.e. 300 microsievert (μSv)) per year, with a requirement to reduce doses as low as reasonably practical below this level (DETR, 2000) (37). In the UK the HPA has calculated that on average people are exposed to about 2.7 millisieverts (mSv) of radiation a year (36).

3.4.30 Radon is of concern because of its association with increased risk of cancer, including lung cancer and leukaemia (38). The risk from radon is approximately 25 times higher for cigarette smokers than for non-smokers (36). The radon smoking interaction represents a potentially important synergistic impact (sum greater than the parts). For people who smoke, the synergistic effects of exposure to radon are multiplied. Synergisms among occupational inhalation exposures are known; perhaps the best documented example is the synergy between radon progeny and cigarette smoking in producing lung cancer in underground miners. In this example, the presence of synergism was shown by a pooled analysis of data that contained information from cohorts of underground miners on both exposure to radon decay products and smoking. Statistical models were used to estimate the degree of synergism, which could be determined with reasonable precision because substantial data were available. This work was recently referenced in meta-analysis in Environmental Health Perspectives (39).

3.4.31 Alpha particle emissions dominate the carcinogenic action of radon and its decay products. The passage of a single alpha particle through the nucleus of a human cell causes complex clustered damage to the DNA. Most cancers are of monoclonal origin and derive from a single damaged cell through a multistage process of genetic changes (36). One radon decay particle is therefore sufficient to cause cancer.

3.4.32 Radon is usually measured in units of becquerels per cubic metre, $Bq/m^3$ (i.e. concentration of radioactivity in air). The average outdoor radon level varies between 5 and 15 $Bq/m^3$. Evidence suggests an increase of 100 $Bq/m^3$ in the long-term average radon concentration

[4] Sievert (Sv) is the international (SI) unit of effective dose, obtained by weighting the equivalent dose in each tissue in the body with ICRP-recommended tissue weighting factors, and summing over all tissues.

[5] Mobbs et al incorrectly reference this legislation. The correct reference is to the Ionising Radiations Regulations 1999, which came into force in 2000. Available at: http://bit.ly/1nS4t64

in the home would cause an increase in the risk of lung cancer of between 5% and 31%. This risk appears to vary linearly with the radon concentration, with no threshold below which the risk is zero (36).

3.4.33 The Ionising Radiations Regulations 1999 (IRR99) (40) radon criterion of 400 Bq/$m^3$ is a workplace threshold above which the responsible employer is required to manage radon exposure of employees and, where appropriate, the public. If the radon measurements do not exceed 400 Bq/$m^3$ in any 24 hour period in the workplace (IRR Reg 3.1(b)), then the occupational and public dose limits will not apply. The ES describes radon exposure in units of microsievert (µSv) rather than Becquerels per cubic metre (Bq/$m^3$). Furthermore data is presented as annual averages rather than 24 hour means. Although the ES modelling results suggest radon exposure will be very low, it is unclear from the data if there are peaks in radon exposure levels (notably during operation of both flares) either within or outside the surface site boundary that would cause IRR99 to apply. It may therefore be appropriate for monitoring to include measures of radon levels as Bq/$m^3$ 24hr means.

3.4.34 The ES modelling of radon to a hypothetical 'local resident family' (living 100m away and eating food grown 500m away) resulted in an effective dose of 0.3 µSv per year. The ES concludes this is not significant. ES Appendix F states that the estimated exposure is considered suitably worst-case, and falls significantly within both the dose constraint of 300 µSv per year for a single source, and the statutory public dose limit of 1,000 µSv per year.

3.4.35 A possible limitation of the modelling is that the model spreads the assumed 120 day flare burn as a discharge over the course of 1 year, to give an annual effective dose. Little further detail is provided, so there is a possibility that (as Radon has a 3.82-day half-life (37)) the annual exposure rate may be lower than for a 120 day period. The ES states that the initial flow test period will be 90 days, during which time gas will be flared from two flares located within the boundary of the site. During the extended flow testing the gas will not be flared, but piped to the gas grid. The 120 days therefore seems reasonable, however only one flare is referred to in the radon modelling.

3.4.36 Regulation of all disposals of radioactive waste, including discharge into the environment rests with the Environment Agency. The Environment Agency acts so as to limit such disposals so that public exposure to radiation is as low as reasonably achievable, and is within national dose limits and constraints, in accordance with the Radioactive Substances (Basic Safety Standards)(England and Wales) Direction 2000 (41).

3.4.37 Although the lack of a lower threshold for harm from radon might suggest it would be desirable for the Environment Agency to require doses as low as reasonably practical, statutory guidance states that where the prospective dose to the most exposed group of members of the public is below 10 µSv per year from the overall discharges of an operator the Environment Agency should not seek to reduce further the discharge limits that are in place, provided the operator applies and continues to apply BAT[6] (42).

3.4.38 On this basis this review concludes that, although the assessment of radon emission may have some limitations, it is likely to be of the correct order of magnitude and this is below statutory values for radiological exposure to the public. Whilst this does not preclude all harm, it would seem to be below the threshold where further mitigation would be expected. Notwithstanding recommendations that exposure should be reduced as far as practical the following issues could be explored:

- Monitoring to confirm the modelled compositions and exposures.

[6] The term BAT means the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste.

- A calculated equivalence of µSv/year to worst case Bq/m$^3$ 24 hour mean for the period of flaring (i.e. not averaged over a year) would be helpful to compare the predicted levels with IR99 target levels.
- It is unclear if the radon model included allowances for weather conditions (which may affect dispersion with distance). For the avoidance of doubt the radon modelling could potentially be re-run with actual rather than hypothetical receptors and weather parameters. This is not expected to alter the ESs conclusion, but would assist in resolving this as an issue for the HIA.

3.4.39 These findings suggested the need for further information on the radon modelling, particularly: on whether there will be periods of higher exposure to radon (e.g. during the 120 day flare period assumed by the radon modelling) than is suggested by the ES reporting the exposure levels as an annual effective dose; whether one or two flares have been modelled; the likely radon exposure levels during unplanned events (e.g. loss of gas containment at ground level) for occupational and residential receptor doses; and results using actual rather than hypothetical receptor and weather data.

3.4.40 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC seeks further specific clarification on this point. For each radon modelling result (including those requested above), data in unit of µSv/year and Bq/m$^3$ 24 hour mean would be useful.

3.4.41 The impact from large scale gas extraction on atmospheric radon emissions is expected to be limited as the gas would be piped to the gas grid not flared. However this should not preclude radon impacts being considered in such assessments, e.g. water based emissions or unplanned loss of gas containment.

### *Conclusion on air quality*

3.4.42 Public health protection is improved when emissions are controlled and facilities are located away from where people live (43). Overall the ES air quality assessment shows that emissions are controlled and the site is situated away from major population centres (although there are a number of dwellings nearby). The air quality modelling of the emissions covered by the ES are suitable to inform the health related assessment of air quality impacts. There are a few areas where additional information could be requested to provide reassurance to the DPH that human health will not be impaired. Other than emergency scenarios, it is agreed that the potential for health impacts as a result of the development's impact on air quality are limited. The full life cycle impacts associated with offsite waste transport and disposal could be an area of further clarification in conjunction with the Environment Agency.

## 3.5 Noise

3.5.1 ES chapter 16 and appendix P assesses noise and vibration impacts of the Project. It concludes that the Project will not result in a significant effect from noise or vibration. Achieving this is dependent upon operational control, such as time of operation, and type of operation.

3.5.2 The noise from flaring of the waste gases has not been included within the ES, though a diagram of a similar type flare has been included in appendix P. The diagram appears to indicate that the noise from its use is 45dB at a distance of 15m. Assuming the stack height to be 10m, the noise will not be attenuated by the earth bund surrounding the pad, which is 5m. It is possible but unlikely that the noise will still be heard at local receptors.

3.5.3 The ES states that vibration will not be felt given the distance of the receptors from the site. This is not the same as seismic activity. Vibration associated with potential microseismic events during hydraulic fracturing is addressed separately in ES Chapter 12.

3.5.4 ES section 16.4.1.7 para 24 notes that National Planning Policy Framework (NPPF) guidance states that: subject to a maximum of 55dB(A)$L_{Aeq,\ 1hr\ (free\ field)}$, mineral planning authorities should aim to establish a noise limit at the noise-sensitive properties that does not exceed background levels by more than 10dB(A). NPPF also notes that in locations where the existing background noise level is low, it would be difficult not to exceed the background noise level by more than 10dB(A) without imposing unreasonable restrictions on the mineral operator and therefore recommends the following freefield356 noise standards:

- Day (07.00 to 19.00 hrs) LAeq,1h as near as practicable to background+10dB(A);
- Evening (19.00 to 22.00 hrs) LAeq,1h not greater than background+10dB(A);
- Night (22.00 to 07.00 hrs) Not greater than 42dBLAeq, 1h.

3.5.5 The ES chapter 16 (noise) notes the site is in a rural location. Noise monitoring, (Appendix P2.5.1) shows a daytime L90 of approximately 42dB at Old Orchard farm, and just 38dB at Roseacre Farm. The background levels of noise are very low. The introduction of any noise into this environment could be both notable and intrusive.

3.5.6 The ES (at 16.4.1.7) suggests that the guidelines contained in NPPF regarding achievement of noise limitation are unreasonably stringent, given that the Framework is aimed at large scale mineral extraction, and the Roseacre Wood site is small and transient. This review notes that it would seem reasonable to interpret it in the reverse way: as a small scale development it should be possible to achieve the limits set for a large scale one. The exceedance by the majority of the Project activities of the NPPF 10dB(A) increase above background is therefore of concern. The ES uses different criteria (see below) from the NPPF guidance which do not require the Projects activities to be mitigated to achieve noise levels as near as practicable to background + 10dB(A).

3.5.7 The ES noise assessment uses the British Standard BS 5228 Part 1 (noise) thresholds (44) which is appropriate to the project being undertaken, being a code of practice for construction and open sites. This includes:

- noise thresholds for specified working hours (see section E.3.2 of that guidance);
- thresholds for insulation of homes for certain exceedances (see section E.4 of that guidance); and
- recommendations for re-housing in certain circumstances (see section 6.3 (g) of that guidance)[7].

3.5.8 The way in which significant health effects are defined is important for HIA. For example noise thresholds for health impacts compiled by the European Environment Agency (45) might suggest that any persistent exceedance of 42 dB $L_{den}$ could potentially be considered a significant negative impact (see Table 3-2). At higher noise levels, persistent strong annoyance significantly elevates relative risks in the cardiovascular system, the respiratory system, and the musculoskeletal system as well as by depression (46).

[7] BS 5228 Part 1 insulation and therefore re-housing thresholds are not exceeded by the Projects predicted residual impacts (assuming that fracturing pumps are operated only during weekday daytime and Saturday mornings).

Table 3-2: Effects of noise on health and wellbeing with sufficient evidence

| Effect | Dimension | Acoustic indicator[8] | Threshold[9] | Time domain |
|---|---|---|---|---|
| **Annoyance disturbance** | Psychosocial, quality of life | Lden[10] | 42 | Chronic |
| **Self-reported sleep disturbance** | Quality of life, somatic health | Lnight[11] | 42 | Chronic |
| **Learning, memory** | Performance | Leq | 50 | Acute, chronic |
| **Reported health** | Wellbeing clinical health | Lden | 50 | Chronic |
| **Hypertension** | Physiology somatic health | Lden | 50 | Chronic |
| **Ischaemic heart diseases** | Clinical health | Lden | 60 | Chronic |

3.5.9 The WHO state that a threshold of 40 dB $L_{night,\ outside}$ should be the target of the night noise guideline to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly (47). Table 3-3 sets out supporting evidence for this threshold.

Table 3-3: Summary of effects and threshold levels for effects where sufficient evidence is available

| Effect | | Indicator | Threshold, dB |
|---|---|---|---|
| **Biological effects** | EEG awakening | LAmax,inside | 35 |
| | Motility, onset of motility | LAmax,inside | 32 |
| | Changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep | LAmax,inside | 35 |
| **Sleep quality** | Waking up in the night and/or too early in the morning | LAmax,inside | 42 |
| | Increased average motility when sleeping | Lnight,outside | 42 |
| **Well-being** | Self-reported sleep disturbance | Lnight,outside | 42 |
| | Use of somnifacient drugs and sedatives | Lnight,outside | 40 |
| **Medical conditions** | Environmental insomnia | Lnight,outside | 42 |

Sufficient evidence: A causal relation has been established between exposure to night noise and a health effect. In studies where coincidence, bias and distortion could reasonably be excluded, the relation could be observed. The biological plausibility of the noise leading to the health effect is also well established.

3.5.10 For the day time, the Community Guidelines from the WHO (48) recommends 50/55 $L_{Aeq,\ 16hr}$ as a health based threshold, which is in line with earlier recommendations and guidance from ISO and national and international environment agencies (45). The WHO Community Guidelines are currently being updated (49). Table 3-4 provides guide thresholds for specific environments from the WHO Community Guidelines.

[8] Lden and Lnight are defined as outside exposure levels.

[9] Level above which effects start to occur or start to rise above background.

[10] Lden is the day-evening-night equivalent level. This is the A-weighted, Leq noise level, measured over the 24 hour period, with a 10 dB penalty added to the levels between 2300 and 0700 hours and a 5 dB penalty added to the levels between 1900 and 2300 hours to reflect people's extra sensitivity to noise during the night and the evening.

[11] Lnight is the night equivalent level Leq. This is the A-weighted, Sound Level, measured overnight 2300 - 0700 hours.

Table 3-4: WHO guideline values for community noise in specific environments

| Specific environment | Critical health effect(s) | Leq [dBA] | Time base [hours] | Lmax, fast [dBA] |
|---|---|---|---|---|
| **Outdoor living area** | Serious annoyance, daytime and evening | 55 | 16 | - |
| | Moderate annoyance, daytime and evening | 50 | 16 | - |
| **Dwelling, indoors** | Speech comprehension and moderate annoyance, daytime and evening | 35 | 16 | 45 |
| **Inside bedrooms** | Sleep disturbance, night-time | 30 | 8 | 45 |
| **Outside bedrooms** | Sleep disturbance, window open (outdoor values) | 45 | 8 | 60 |
| **School class rooms and pre-schools, indoors** | Speech intelligibility, disturbance of information extraction, message communication | 35 | during class | - |
| **Pre-school bedrooms, indoors** | Sleep disturbance | 30 | sleeping-time | 45 |
| **School, playground outdoor** | Annoyance (external source) | 55 | during play | - |
| **Hospital, ward rooms, indoors** | Sleep disturbance, night-time | 30 | 8 | 40 |
| | Sleep disturbance, daytime and evenings | 30 | 16 | - |
| **Hospitals, treatment rooms, indoors** | Interference with rest and recovery | #1 | | |
| **Industrial, commercial shopping and traffic areas, indoors and outdoors** | Hearing impairment | 70 | 24 | 110 |
| **Ceremonies, festivals and entertainment events** | Hearing impairment (patrons:<5 times/year) | 100 | 4 | 110 |
| **Public addresses, indoors and outdoors** | Hearing impairment | 85 | 1 | 110 |
| **Music through headphones/ earphones** | Hearing impairment (free-field value) | 85 #4 | 1 | 110 |
| **Impulse sounds from toys, fireworks and firearms** | Hearing impairment (adults) | - | - | 140 #2 |
| | Hearing impairment (children) | - | - | 120 #2 |
| **Outdoors in parkland and conservation areas** | Disruption of tranquillity | #3 | | |

#1: as low as possible
#2: peak sound pressure (not Lmax, fast), measured 100 mm from the ear
#3: existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low
#4: under headphones, adapted to free-field values

From WHO (48)

3.5.11 The ES noise chapter distinguishes noise impacts from various activities, including: construction, traffic, drilling and hydraulic fracturing.

### *Drilling*

3.5.12 Drilling will be an operation which is continuous 24 hours per day, seven days per week. Well 1 is expected to require 5 months of drilling, wells 2-4 will take approximately 3 months each. Wells will be drilled sequentially.

3.5.13 Once a drill hole is commenced, it is operationally imperative to complete it, otherwise drilling equipment may be damaged. Four separate occasions of drilling may take place, once for each well.

3.5.14 ES table 16.11 sets out the predicted noise levels from drilling operations. Three receptors are listed. Old Orchard Farm is predicted to experience noise levels of 45 $dBL_{Aeq}$, Roseacre

Farm 41 $dBL_{Aeq}$ and Stanley Farm 39 $dBL_{Aeq}$. During the daytime these levels are acceptable from a health point of view as they appear to be below the WHO recommended threshold of 50/55 $L_{Aeq,\ 16hr}$ (48). However during the night time these levels are above the recommended WHO threshold of 40 dB $L_{night,\ outside}$ (47), at Old Orchard Farm and Roseacre Farm. As the exceedances are relatively small, mitigation (such as sound attenuating barriers) may be a viable solution. The ES uses a threshold of 45 $dBL_{Aeq}$ for night time. Judged against these criteria (which is the lowest values of the ES methodology (44)) the ES finds there are no significant impacts.

### *Hydraulic fracturing*

3.5.15 The ES reports that the only stage of the project with the potential to result in a significant noise effect is where hydraulic fracturing occurs during night time (23:00-07:00) where noise limits are at their most stringent. A restriction in working hours is therefore proposed for the pumping and fracturing. This will be between 07:00-19:00, Monday to Friday; and 07:00-13:00 on Saturday.

3.5.16 The ES reports that the noise associated with hydraulic fracturing is principally from the hydraulic pumps. No other noisy equipment is operated during the rest of the hydraulic fracturing process. Hydraulic fracturing will require 30-45 stages per well, each stage requiring the pumps to operate for approximately 3 hours. The hydraulic fracturing of each well is anticipated to last approximately two months. There are four wells. Wells will be hydraulically fractured sequentially.

3.5.17 ES table 16.13 sets out the predicted noise levels from hydraulic fracturing operations. These represent the most significant noise impact reported by the ES. Three receptors are listed. Old Orchard Farm is predicted to experience noise levels of 64 $dBL_{Aeq}$, Roseacre Farm 60 $dBL_{Aeq}$ and Stanley Farm 58 $dBL_{Aeq}$. The ES uses a threshold of 65 $dBL_{Aeq}$ for week days and Saturday mornings and 55 $dBL_{Aeq}$ for weekday evenings, Saturday afternoons and Sundays. Judged against these criteria (which are the lowest values of the ES methodology (44)) the ES finds there are no significant impacts if operations are limited to week days (07:00-19:00) and Saturday mornings (07:00-13:00). From a HIA perspective the results appear to exceed the WHO recommend threshold of 50/55 $L_{Aeq,\ 16hr}$ (48).

### *Conclusion on noise impacts*

3.5.18 Notwithstanding the difference in thresholds that could be used in HIA as opposed to EIA, the methodology used by the ES noise assessment appears appropriate for an EIA. The modelled results could form the basis for more detailed HIA evaluation. To do so the values need to be converted to the time bases used in Table 3-2, Table 3-3 and Table 3-4. Such conversions could be requested from the ES consultants.

3.5.19 As noted in the preamble to this review such a request would normally fall within the iterative HIA process. An alternative to requesting that all ES data is provided in alternative units and a subsequent reanalysis of the results would be for commitments to be given that conservative health thresholds will be met. We suggest that the Director of Public Health for LCC request additional mitigation be incorporated into the Project to ensure that at all receptors noise levels attributable to the Project (notably well pad construction, drilling and hydraulic fracturing) neither exceed the WHO general health based threshold of 50/55 dB $L_{Aeq,\ 16hr}$ (48); nor the WHO night noise threshold of 40 dB $L_{night,\ outside}$ (47). This recommendation is aligned with the HIA objective of minimising health impacts, rather than meeting statutory or regulatory limits.

3.5.20 As the thresholds applied by the ES suggest there will be no significant impacts, the noise chapter only specifies minimal mitigation. This includes usual best practice for operating machinery and vehicles; selection of quieter plant and equipment; and as far as is practicable, placing plant in screened positions to minimise noise emission in the direction

of dwellings. As an HIA can consider current levels of understanding of impacts on health, as yet not incorporated into legal limits it may be appropriate for the application to consider noise attenuating screening or other mitigation. Although there may be some visual impact, noise barriers should be a relatively straightforward addition (unless a significant noise source exists high on the drilling rig or other plant). The ES states that the site and access road will be secured by a 4m high welded mesh security fence. A solid rather than chain link type fence could contribute to noise mitigation, a specialised noise barrier more so. Such screening is unlikely to reduce all noise associated with the Project below the NPPF limits of background + 10dB(A). In addition to robust procedures for receiving and responding to noise complaints, ongoing monitoring at sensitive receptor locations will be important. These should include Roseacre Farm, Old Orchard Farm and properties in Roseacre village.

3.5.21 With regard to mitigation of the potential noise impacts from hydraulic fracturing, the ES notes that the most effective and efficient mitigation would be to manage the works so that fracturing pumps are operated only during weekday daytime and Saturday mornings.

3.5.22 As noted the ES draws its threshold data for Saturday 07:00-13:00 from British Standard BS 5228 Part 1 (noise) thresholds (44). Although this guidance allows for less stringent thresholds on Saturday mornings, compared to the rest of the weekend, Saturday is not part of the traditional 5-day working week. The appropriateness of causing disturbance on a Saturday morning is therefore debatable.

3.5.23 Based on this reviews findings and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC requests regulatory authorities to control the working hours and days for Project activities, particularly hydraulic fracturing. Consideration could be given to only operating the hydraulic fracturing pumps during weekday daytime and ceasing activity during weekends and bank-holidays.

3.5.24 This review notes that the frequency spectrum and time-structure of the Project's predicted noise will determine whether it is clearly audible against background levels even if they are of similar decibels.

3.5.25 These findings suggested the need for further reporting of the frequency spectrum and time-structure of noise attributable to the Project to evidence that it will not be clearly audible against background levels.

3.5.26 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC seeks further specific clarification for noise impacts attributable to the Project which are justified on the basis of being of a similar decibel level to background noise. The request should be for further reporting of the frequency spectrum and time-structure of such noise to establish whether it will be clearly audible against background levels.

## 3.6 Hydrogeology and Ground Gas

3.6.1 ES chapter 11 assesses hydrogeology and ground gas impacts of the Project, and is supported by Appendix K. It notes that the well pad and wells themselves have been designed so that leaks or spills do not enter the wider environment (the soil above the wells, groundwater, surface water or the atmosphere) and lead to pollution or contamination. The chapter states that when drilling through potentially sensitive rock

layers only drilling fluids which are non-hazardous to groundwater will be used. This may change as the deeper rock strata are penetrated, when LTOBM (Low Toxicity Oil Based muds) may be used. The chapter concludes that the Project will not result in a significant effect on hydrogeological features. The chapter notes that prior to and during exploration works ground and surface water quality will be monitored. When the wells are no longer needed they will be decommissioned following the guidance from relevant regulatory bodies (Environment Agency, DECC and the Health and Safety Executive).

3.6.2 The ES chapter 11 hydrogeology and ground gas covers a range of issues relevant to health. These include water contamination and gas migration. The ES chapter states that it considers off-site human health, on-site human health (site workers and visitors) and crops and livestock (potential food chain impacts). Later in the chapter the ES states that site management will be compliant with relevant health and safety legislation and will be regulated by the Health and Safety Executive (HSE). As such risks to site workers and visitors ('on-site human health receptors') associated with activities on the pad are not considered explicitly in the assessment. This is not an unusual approach to adopt. Further HIA work could consider on-site receptors, including emergency scenarios.

3.6.3 The ES describes the relevant management procedures that will be in place. These include the Applicant's Health Safety, Security and Environment (HSSE) Risk Management Framework for operational risks. The ES chapter also states that the implementation of the site health and safety procedures, record keeping, monitoring and auditing will be regulated by the HSE. Whilst the HSE have a role to play, it should be noted that the HSE's remit covers the health and safety of the work force and any members of the public who may visit the site. Limits which apply for personal exposure over an eight hour working day are different from those for a twelve month period for people outside the site boundary. That being said, HSE will be keen to ensure that catastrophic failure does not occur. Consultation findings suggest this is an area of concern for the public.

3.6.4 The ES notes that the site will be operated under an Environmental Permit, regulated by the EA, which will require that the design and operation of the regulated activities on the site meet the necessary standards described as Best Available Techniques (BAT).

3.6.5 The ES reports that groundwater is not widely exploited in the central and western Fylde.

3.6.6 Protection of groundwater and ultimately aquifers is a complex and inter-related part of this application. It relates to protection of aquifers and surface water bodies from: spills at the surface of the operation; direct contamination during the drilling process; contamination during the introduction of hydraulic fracturing fluid; and the inter-relationship and mobility of groundwaters and introduced fluids. As such, several chapters of the application and appendices are referenced here.

3.6.7 ES Appendix C, the EIA scoping report, states (para3.1) that the main reason for the work 'is to determine the productivity of gas and associated liquid hydrocarbons'. It is presumed that the terminology 'liquid hydrocarbons' refers to petroleum, as oil and gas are fossil fuels which form together under similar conditions. It may be reasonable to infer that where fracking fluid is found, there will also be oil. This is naturally occurring oil which, if left in its confined and undisturbed state, would be unlikely to pose a threat to groundwater.

3.6.8 However, the ES does not present evidence that petroleum will be part of the process: the waste section does not refer to oily waste or oil-contaminated NORM. There is no reference to the collection of and sale (or use) of crude oil. The groundwater protection does not consider the mobility of oil between rock formations and deep water bodies. There is, however, reference to it within the IPPC application, within the Application

Supporting Document, which describes the detail of operations, such that the EA can create a permit which is appropriate to the site, size and scale of operation. Page 28 of the waste management plan indicates that flowback fluid will be visually assessed for oily waste, and if it appears to be oily it will be analysed. No plan appears to have been presented for abstracting oil, nor dealing with oil-contaminated waste. This issue applies to both sites (Roseacre Wood and Preston New Road).

3.6.9 Groundwater protection is important to ensure that resources remain available in a useable form for any future generations. This report comments on protection of human health now and in the future; in the near vicinity and at a distance. It is not constrained by legal limits, but offers observations on the impact of the Project on health.

3.6.10 The ES and associated documents assert that groundwater will be protected at all times, in several ways. These are discussed further below.

3.6.11 The Environment Agency has responsibility for providing a permit to operate, under the Environmental Permitting Regime 2010, within which they have a role in ensuring that water bodies, both surface water and groundwater are protected, be that from the introduction of pollution, whether deliberate or accidental, and from over abstraction (50). This includes assessment of the groundwater as having the potential (treatment may be involved) to be drinking water, at some unknown time in the future.

3.6.12 The documentation of the permitting application (which includes the ES) for this Project describes its ability to protect groundwater based on several assumptions.

- 1: drilling through surface rocks including the Sherwood aquifer will be done without the use of chemicals.
- 2: casings will be provided which go below the Sherwood aquifer and below the Manchester marls, making the assumption that the Manchester marls provide a barrier to upward migration of pollutants.
- 3: fracturing fluid which contains low toxicity oils may be introduced to the shales only below the Manchester marls and protective casing.
- 4: the groundwater in the shales is not of drinking water quality, due to its intrinsic salinity.
- 5: lateral movement of fracking fluid into potential aquifers will be restricted by the presence of faults in the rock strata.
- 6: movement of fracking fluid will not migrate above the Manchester marls because the induced fractures will be subject to limitation by use of the seismic traffic light system.

3.6.13 Some of the assertions and assumptions which have been made would need further investigation. Rock strata do not exist in isolation. That is to say, seeing a 2D diagram of the rocks which are to be drilled does not place them in the wider context. Groundwater migrates and recharges at variable rates, sometimes relatively rapidly, over a few days, and sometimes extremely slowly, over many years. This variability informs the EA ruling (50) on not polluting groundwater which may not seem to be potable at the moment, but which may become so at some point in the future.

3.6.14 The ES states that the Woodsfold fault provides a line of demarcation between potable water, and more saline water, and thus the use of fracking fluid will remain isolated. However, induced seismicity may change the way in which faults behave, and allow fracking fluid to cross the faults (51). The proximity of the Roseacre site to the Woodsfold fault is noted (approximately 2.6km at the surface – see ES figure 11.1). Although the hydraulic fracturing will be directed away from the fault, the risk of interactions with the fault would appear to be increased compared to activities at the Preston New Road site.

3.6.15 There is also an assumption that upward migration will not occur. The millstone grits and Collyhurst seams which lie above the Bowland shales outcrop further south and east, and have been assessed by the EA and BGS in a study on groundwater (52;53). The descriptions of the continuity of halite and unpredictability of the strata suggest that there will be little upward or lateral protection. In addition, the millstone grits are low -grade aquifers in their own rights. Furthermore, the assumption that fractures have a limited capacity to proliferate (54) has been questioned (55).

3.6.16 Wider studies on the potential for drilling and fracking to cause pollution to groundwater have been carried out by the British Geological Society, including the impact on the Bowland shales, and their comparison with American shales (56). This work indicates that there is still a great deal of uncertainty, though since the time that the paper was published the UK regulatory regime has changed, and has been tightened to oversee the permitting and operating of UK wells.

3.6.17 There has been a great deal of media coverage of the negative elements of 'fracking' in the US, which has been extrapolated to the UK. In addition to the areas of concern already covered with regards to groundwater, methane in drinking water is an issue. The methane which is to be extracted is deep methane, (thermogenic) which has a particular 'fingerprint', and enables it to be distinguished from biogenic methane which migrates to the surface from old landfill sites, bogs, and other points of breakdown. This methane has been the object of recent study in order to determine background levels prior to hydraulic fracturing being permitted (licenced) in the UK (57). There is data specifically available for the North West of the UK, but to date this does not cover the area to which this application pertains.

3.6.18 This review notes that there are uncertainties associated with some of the assumptions made in the application regarding reliance on geological barriers. It also notes the reliance on best practice and adherence to any local management plans in order to avoid impacts to groundwater and surface water, with associated detriment to human health.

3.6.19 These findings suggested the need for further information on the reliability of geological barriers to safeguard direct or indirect ground water human health impacts. It is noted that whilst one of the objectives of the application is to increase knowledge about the geology, monitoring of how the geology interacts with project activities will also be important.

3.6.20 We suggest that the Director of Public Health for LCC requests updates from the EA to be assured that:

- baseline data on methane in water is understood for the proposed operational area;
- emerging knowledge on fracture proliferation continues to inform monitoring requirements;
- there is monitoring of how the project's activities affect the permeability and mobility of surrounding geological strata and natural fractures (notably the Woodsfold fault) to ground water;
- the DPH is informed of any breach of regulation which may occur in the future should this application be granted; and
- monitoring regimes take account of long-term migrations and the potential deterioration of the well over time.

3.6.21 The ES describes how the drilling stage will use drilling mud with non-hazardous chemicals for going through aquifers, shallow section and other sensitive formations. Drilling at other times will use additives that may be hazardous. If drilling encounters a fault there may be an unrecoverable loss of drilling fluid. This could occur at any depth. The mobilisation of hazardous drilling mud additives into groundwater that is or may be abstracted is a

potential health impact. The ES describes monitoring for loss of drill mud pressure in combination with encountering known fractures. Where drilling mud pressures markedly drop this will trigger drilling to stop. A location that may be particularly sensitive for the Roseacre Wood site is drilling goes through the Mid-Elswick Graben Faults which adjoin the Woodsfold fault (which separates the site from potable water abstraction). Loss of toxic drilling muds here would be a concern. Drilling through the faults creates a potential pathway for migration of pollutants. Every fault encountered and breached increases the potential for loss of containment. We suggest that the Director of Public Health for LCC seeks clarification as to whether non-hazardous drilling mud will be used when drilling through the Mid-Elswick Graben Faults. Alternatives to drilling through the fault could be set out.

3.6.22 In addition to causing contamination of drinking water, methane is an explosive gas. It is able to migrate through rock strata and may build up in confined occupational and residential spaces, presenting a hazard to health.

3.6.23 The ES identifies possible hazardous ground gases as methane, carbon dioxide, carbon monoxide, hydrogen sulphide and radon. The ES considers methane to be the main risk driver for human health impacts from loss of gas containment. The ES assumes that as the potential pathways to human health receptors are expected to be long in terms of distance and travel time through the ground/groundwater radon is not considered to be a potential ground gas hazard due to its short half-life.

3.6.24 The possibility that induced fractures might intersect natural faults or other discontinuities (such as existing deep boreholes) providing a pathway for contaminants or gases to enter shallower formations has also been evaluated. The ES reports that the fracturing programme has been designed to keep induced fractures offset from regional faults by a distance of two times the anticipated fracture length. This will be achieved using microseismic monitoring. The ES does not specify the reliability of this method (based on micro-seismic events) to accurately determine the surrogate outcome of fracture propagation. It is a retrospective technology- that is to say the monitors will monitor in real time, and any adverse ground activity which is monitored will require that the pumping and fracturing stops. At that time it is possible that the fractures will have moved further than the operator would like. The ES assumes that any unidentified fault is unlikely to stretch far enough to pass through natural impermeable layers. Even with such a route the ES finds that gas volumes would be small and greatly dispersed before they reached human receptors. The ES concludes that as multiple pathways must coincide for this risk to be realised, no plausible pathway is considered to exist. Whilst such a conclusion appears reasonable, further consideration could be made of any potential impact from long-term low level gas permeation to the surface, both on human receptors and climate change.

3.6.25 With regard to ground gas migration the consequences are not considered as the ES finds that ‘no plausible pathway’ has been identified. The ES methodology notes that where multiple pathways are required to realise the risk the probability of all the required pathways coinciding must be considered. The probability of all the required pathways coinciding may be so low as to be considered negligible, i.e. there is no plausible linkage, and therefore it is not appropriate to assign a risk magnitude. This is the case for a number of potential risks initially identified as a result of public concerns. How such risk assessment findings affect people's understanding of the risks is a matter that could be explored further under perception effects.

3.6.26 These findings suggested the need for further information on long-term low level gas permeation to the surface including permeation to the surface which may be distant to the proposed site.

3.6.27 Based on this reviews findings and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC requests further information on how the application will affect long-term low level gas permeation to the surface including permeation to the surface which may be distant to the proposed site. Estimates of potential surface concentrations and areas of effect would be helpful. We suggest that the DPH remains in close contact with the EA on order to be appraised of changes to scientific knowledge which may have a bearing on the Project.

3.6.28 These findings also raise the need for further information on what action could be taken in the event that a significant pathway, along a fault or other discontinuity, may be established for gas to the surface.

3.6.29 Based on this reviews findings and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC seeks further specific clarification on long-term low level gas permeation to the surface.

3.6.30 In terms of loss of well integrity due to natural seismic events, the ES assumes a very low probability of a significant natural seismic event being in close proximity to the Project site. Although this seems a reasonable assumption, consideration of such unplanned events could be included, ideally supported by a Quantitative Risk Assessment (QRA). It is not clear whether a QRA has been produced. There is a brief qualitative risk assessment (Appendix K section 2.5, source 2) however this provides little additional information. Scenarios in addition to earthquakes could also consider loss of the surface infrastructure due to fire, vehicle strike or aeroplane strike. The ES does not describe the installation of a remotely operated shut off valve below ground level, which is understood to be a standard industry feature. ES Appendix K notes that the uncontrolled release of formation fluids (oil, gas and/or water) from the well (blowouts) are rare, but usually related to human error and/or multiple equipment failure that occurs as a result of a series of failures: in observation; to properly react; or to properly maintain and test equipment. Blowouts may take hours to days to contain. It is noted that the compliance with regulatory and management regimes to avoid human error is a critically important aspect of the safety of this development. However such frameworks are largely detailed post application determination. The environmental management plan outlined in Appendix E is currently an outline of the section required to create an EMS, not an operational document. The weight placed on such regimes in mitigating risks of the development is noted.

3.6.31 The ES notes the potential for loss of well integrity and subsequent gas migration from degradation of the well following abandonment (if that option is adopted). Whilst the ESs plan to monitor for a year after abandonment is supported, the probability of degradation increases with time. The ES notes that degradation over decades could result in migration of contaminants into soils or ground water. This issue should be considered in more detail. One option might be additional monitoring (not necessarily continuous), e.g. at year 2, 5, 10, 20, 30 etc…. We suggest that an appropriate timescale for monitoring should be identified in a literature review. It will be important that the development does not result in adverse legacy issues for air, ground or water contamination. The ES is unclear on the Applicant's responsibility for the site post abandonment/ decommissioning.

3.6.32 These findings suggested the need for further information on how long the Applicant will monitor the site following abandonment to ensure there are no adverse legacy issues for air, ground or water contamination.

3.6.33 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC requests that regulators require an appropriate long-term monitoring plan post decommissioning / abandonment to ensure that the Project does not cause adverse legacy issues for air, ground or water contamination. Responsibility for monitoring should be clearly defined and set through condition, legal agreement and / or bond. The Director of Public Health for LCC should remain engaged with the monitoring information that emerges from the planning and permitting processes.

3.6.34 ES chapter 11 paragraphs 284-289 summarise the ES hydrogeology and ground gas conclusions in relation to human health. This section includes consideration of:

- exposure to contaminated water in a watercourse downstream of the site (potentially affecting people, livestock and crops);
- equipment failure releasing fluids at high pressure as a spray off site (potentially affecting people, livestock and crops); and
- spillage of contents of a vehicle due to a road traffic accident.

3.6.35 The ES concludes that the consequence of all these potential exposures is low. The ES defines low consequence as a: minor environmental effect which may breach a regulatory standard but is localised to the point of release with no significant impact on the environment or human health. Again avoidance of and response to such incidents is an issue for regulatory and management regimes. If these are followed the conclusion of the ES are reasonable.

## 3.7 Greenhouse Gas Emissions

3.7.1 ES chapter 8 assesses greenhouse gas (GHG) impacts of the Project. It concludes that the Project carbon footprint is assessed as between 118,419 (lower range) to 124,369 (higher range) tCO2e. The chapter notes that the uncertainty about the potential flow rate of natural gas is one of the questions the Project is trying to answer. The greatest source (approximately 70%) of the project GHG emissions come from burning the gas in the flare during the temporary (maximum 90 days per well) initial flow testing phase.

3.7.2 The Intergovernmental Panel on Climate Change (IPCC) released its latest report in March 2014. This report was the second instalment of the Fifth Assessment Report, prepared by Working Group 2, on impacts, vulnerability, and adaptation to climate change. Chapter 11 specifically addresses human health (58). The following is a summary of key findings.

- The health of human populations is sensitive to shifts in weather patterns and other aspects of climate change [very high confidence].
- Until mid-century climate change will act mainly by exacerbating health problems that already exist [very high confidence].
- If climate change continues as projected until mid-century, the major increases of ill-health compared to no climate change will occur through:
  - Greater risk of injury, disease, and death due to more intense heat waves and fires [very high confidence].
  - Increased risk of under-nutrition resulting from diminished food production in poor regions [high confidence].
  - Consequences for health of lost work capacity and reduced labour productivity in vulnerable populations [high confidence].
  - Increased risks of food- and water-borne diseases [very high confidence] and vector-borne diseases [medium confidence].

- Impacts on health will be reduced, but not eliminated, in populations that benefit from rapid social and economic development [high confidence].
- In addition to their implications for climate change, essentially all the important Climate Altering Pollutants (CAPs) other than $CO_2$ have near-term health implications [very high confidence]. In 2010, more than 7% of the global burden of disease was due to inhalation of these air pollutants [high confidence].
- There are opportunities to achieve co-benefits from actions that reduce emissions of CAPs and at the same time improve health. Among others, these include:
  - Reducing local emissions of health-damaging and climate-altering air pollutants from energy systems, through improved energy efficiency, and a shift to cleaner energy sources [very high confidence].
  - Designing transport systems that promote active transport and reduce use of motorized vehicles, leading to lower emissions of CAPs and better health through improved air quality and greater physical activity [high confidence].

3.7.3 Department of Energy and Climate Change (DECC) recently published a position statement on fracking and climate change (59). That report made the following points:

- The process of extracting shale gas, which includes exploratory drilling, hydraulic fracturing, gas production and well abandonment phases, has the potential to release methane – a powerful greenhouse gas – into the atmosphere. These emissions could increase the carbon footprint of shale gas. In large quantities, it could lessen the climate benefits of using natural gas over oil or coal.
- In most cases, there is no economic use for the gas at exploration stage and flaring (burning it off) is the best option to minimise the emissions. Flaring reduces the greenhouse gas emissions by about 80% compared to simply allowing it to escape into the atmosphere. In production operations, operators will normally capture as much of the methane as possible and export it by pipeline.
- Existing regulatory controls require operators to minimise venting (though this is sometimes necessary for safety reasons) and to make use of gas wherever possible (either on the site or by exporting it) rather than flaring it.
- Technologies that can help prevent greenhouse gas emissions from shale gas sites already exist. During exploratory drilling, operators can capture methane from the fracking fluid which flows back up the well with “green completions” equipment and techniques, and the methane can then be flared.
- A recent study by DECC Chief Scientist David MacKay examined the carbon footprint and climate change implications for UK shale gas. The study found that the carbon footprint for shale gas is significantly less than that for coal when used for electricity generation (423 – 535 gCO2e/kWh(e) versus 837 – 1130 gCO2e/kWh(e)). The study also found that, if well regulated, local greenhouse gas emissions from shale gas operations should represent only a small part of the carbon footprint. Most carbon emissions will come from its final use as a fuel.

3.7.4 DECC concludes that it is in the national interest for future oil and gas to be produced in the UK, under UK environmental and safety standards. DECC places a primacy on the regulatory regime to protect people and the environment, and ensures safe working. We note the emphasis placed on regulation.

3.7.5 As greenhouse gas emissions have the capacity to contribute to global warming, and via climate change, health, it is pertinent to consider the part the project may play in either contributing to or detracting from global warming.

3.7.6 Other gases in the atmosphere have a global warming potential too (see Table 3-5). For example methane, of interest in this case, has a global warming potential (GWP) 24 times

greater than that of $CO_2$. Other gases are greater still. The precise composition and volumes of gases that will be produced by the wells is unknown (determining this information is the main objective of the exploration phase). The project's impact on climate change (and therefore health impacts associated with climate change) is therefore not clear.

### Table 3-5: 100-year global warming potentials relative to $CO_2$ for ozone-depleting substances and their replacements

| Designation or name | Formula | 100-year GWP (SAR) | 100-year GWP (AR4) |
|---|---|---|---|
| Key greenhouse gases | | | |
| Carbon dioxide | $CO_2$ | 1 | 1 |
| Methane | $CH_4$ | 21 | 25 |
| Nitrous oxide | $N_2O$ | 310 | 298 |
| Hydrofluorocarbons (HFCs) | | | |
| HFC-23 | $CHF_3$ | 11,700 | 14,800 |
| HFC-32 | $CH_2F_2$ | 650 | 675 |
| Perfluorinated compounds | | | |
| Sulphur hexafluoride | $SF_6$ | 23,900 | 22,800 |
| Perfluoromethane | $CF_4$ | 6,500 | 7,390 |
| Perfluoroethane | $C_2F6$ | 9,200 | 12,200 |
| Perfluoropropane | $C_3F_8$ | 7,000 | 8,830 |
| Perfluorobutane | $C_4F_{10}$ | 7,000 | 8,860 |
| Perfluorocyclobutane | c-$C_4F_8$ | 8,700 | 10,300 |
| Perfluoropentane | $C_5F_{12}$ | 7,500 | 13,300 |
| Perfluorohexane | $C_6F_{14}$ | 7,400 | 9,300 |

Adapted from Hull (60)

3.7.7 The Applicant has suggested that the fracked gas may be better for the atmosphere when burned, in comparison with either coal or natural gas, which it would be expected to replace. This is based on the fact that the methane will burn more completely, and produce less $NO_x$ (another GHG). Although combustion of methane may compare favourably, fugitive emissions of methane during the extraction process may contribute more to climate change than the savings from less GHG intensive combustion. The fugitive emissions should include: unburnt methane; fugitive methane from wells at the time of drilling; and emissions from unworked (abandoned) wells. It is noted that minimising GHG emissions from fugitive emissions or flaring is important for local, regional, national and international receptors of climate change impacts.

3.7.8 It is accepted that compared to venting methane to the atmosphere, flaring has a lower impact on climate change. However as no use is made of the flared gas (either heating or power generation) it does not replace other climate altering emissions. ES section 8.7.5 describes flaring as 'a necessary part of the Project' because it allows the quantity and rate of natural gas to be determined'. It should be confirmed that flaring represents the BAT for taking these measurements without undue climate change (and other air quality) impacts.

3.7.9 Notwithstanding DECC's (59) acknowledgement that in most cases there is no economic use for the gas during the exploration phase, there is clearly a climate change case for capture rather than release or flaring. The ES Chapter 5 on alternatives does not consider making any use of the collected methane from the 90 day initial flow testing stage of the exploratory fracking other than flaring it.[12] Given that flaring is the primary source of air pollution from the application (including carcinogenic radon), some clarification could be

[12] Coal methane is seen as a resource to be contained and ultimately exploited (61;62).

sought as to whether some other use would be more appropriate (the economic case aside).

3.7.10 These findings suggested the need for further information on what alternatives have been considered for the capture and the use of methane during the 90 day initial flow testing stage and how the decision to flare has been reached.

3.7.11 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC seeks further specific clarification on alternatives to flaring and any long-term post abandonment impact on climate change as the well integrity degrades, potentially creating a pathway for methane to the surface.

3.7.12 Not all the gas liberated by the hydraulic fracturing process would be collected. The nature of the gas means it will migrate through natural fissures in the rock, and ultimately be released at a later date. This issue is also raised in the discussion of the ES air quality chapter – see section 3.4. The uncertainty associated with this means that the contribution to GHGs and climate change is impossible to quantify. To some degree it will depend upon the efficiency of the operator's ability to abstract the majority of the gas which will be liberated. Long-term management of abandoned wells will be important.

## 3.8 Community and Socio-economics

3.8.1 ES chapter 9 assesses the community and socio-economics impacts of the Project. It concludes that the temporary and relatively small scale nature of this Project means that it will not result in a significant effect on communities or socioeconomic factors. The chapter notes that it is assumed that public order and people management will be maintained by the local police force in the event of any protest or criminal activity. The chapter notes the following potential for beneficial effects:

- opportunities for local businesses to provide services to the project;
- community benefit payments for each exploration well; and
- the Project will support approximately 11 full time equivalent jobs.

3.8.2 The area for proposed development is in Fylde, which is an area of relative affluence, and below average deprivation (63). It is, however, an area in which the population currently has a higher than usual number of over 64 year olds. This is predicted to rise. The area appears to have been selected by many residents as a rural retirement location. This suggests that the jobs which are predicted to be created should this project progress will be of little interest to the majority of the residents. The proposed project area is adjacent to Blackpool, which although it has a different profile, being much younger, it has a higher than average transient population, with low skills who may not benefit from the available job opportunities(64).

3.8.3 The ES community and socio-economics chapter states that it is likely that staff will be drawn from outside the local area, due to the specialist requirements. Direct employment in the local area from the Project is therefore likely to be very limited despite the Applicant noting that as a mitigation measure it will consider sourcing staff from the local employment base, where practicable.

3.8.4 The Lancashire area from Preston northwards, and into which the proposed development sits, is traditionally an area of employment for engineers with specialist skills, with Heysham Nuclear Power Station to the north and Salmesbury BAE systems defence construction to the east.

3.8.5 The Preston City Deal (65) which is supported by the Local Enterprise Partnership (LEP) notes: "significant opportunities exist for Lancashire to capture the economic benefits of local shale gas reserves, which are the largest in Europe". However, the ES identifies few direct or indirect economic benefits for Lancashire from the current Project.

3.8.6 In addition to Heysham, the locality has a nuclear research facility at Springfields. This facility is due to expand its production to manufacture the fuel for the recently agreed nuclear facility in Cumbria. Note, this facility has not been considered in the context of interaction of the proposed fracking and hazard evaluation.

3.8.7 Existing homes (as opposed to projected homes) which may be impacted by this Project are unlikely to feel the benefit of the potential employment opportunities afforded should the Project progress. The Applicant also considers the potential for the Project to create knock on jobs: small enterprises such as local shops which may be opened to service the workforce. Given the limited employment associated with the application the indirect employment and indirect economic benefits to the local economy are likely to be very modest.

3.8.8 DECC notes the following benefits to the community (66):

- at exploration/appraisal stage, the industry will provide £100,000 in community benefits per well-site where fracking takes place; and
- at production stage, paying 1% of revenues to communities. Industry estimates this could provide £5-10m per well, spread over 25 years, but mostly in the first 10.

3.8.9 The ES notes there will be a community benefit payment of £100,000 per drilled well (i.e., up to £400,000 for four wells) paid to local communities. It is unclear how this money will be allocated or if those most affected by the adverse impacts of the Project will benefit. The requirement for 1% of revenues at production stage is not mentioned despite the extended flow testing stage potentially providing up to two years of gas supply to the gas grid. Whether this activity constitutes exploration or production is debatable. How this money is distributed and used will be important. For example if placed in a community fund and invested, the income from the fund could provide important ongoing inter-generational community benefits long after gas projection has ceased.

3.8.10 Although the ES community and socio-economic chapter states that the assessment looks at the receiving community and socioeconomic context in terms of housing, there is no discussion of the potential for local house prices to be adversely affected by the Project.

## 3.9 Induced Seismicity

3.9.1 ES chapter 12 assesses the induced seismicity impact of the Project. It concludes that as mitigation measures have been embedded into the design and approach to the Project, the Project will not result in a significant effect. The main embedded mitigation measures are:

- a review of available information on geology and structure (including faults) in the vicinity of the proposed stimulations;
- avoiding drilling wells into, or close to, existing pre-stressed regional faults;
- assessing the risk of hydraulic fracturing to trigger earth tremors;
- when undertaking hydraulic fracturing reduce volumes of hydraulic fracturing fluids used and allow the fluid to flowback between hydraulic fracturing stages;
- carrying out small scale hydraulic fracturing prior to the main hydraulic fracturing activities;
- monitoring background induced and natural seismicity before, during and after the hydraulic fracturing; and
- implementing of the Traffic Light System.

3.9.2 The ES chapter on induced seismicity notes that there are a number of faults in the area (paragraphs 52-59 of the ES). Later in the chapter ES paragraph 142 states that the location of the site selected by the Applicant to construct the vertical and horizontal well has taken into account the geological and structural conditions in the region and the vertical well and the horizontal wells have been located in the most favourable ground conditions to minimise the risk felt from induced seismicity from shale gas exploration operations.

3.9.3 The ES (Section 12.7.3 para 87) acknowledges that they will drill through several faults. ES figure 12.1 suggests that the well (vertical pilot hole) will pass through the Mid-Elswick Graben faults. Figure 12.1 of the ES is a two dimensional side view section so it is useful to view this alongside the corresponding horizontal sections of Figures 7-9 of ES appendix L. Figure 8 of ES appendix L shows the Roseacre wood site directly above the Mid-Elswick Graben faults. The Mid-Elswick Graben faults appear to extend to the Woodsfold fault and intersect the Elswick-1 Well (see Figure 7 of ES appendix L). Drilling through the faults places greater uncertainty on the integrity of the wellbore (e.g. damage from seismic movements of the fault). Every fault encountered and breached increases the potential for loss of containment.

3.9.4 The traffic light system has been approved by DECC, to whom the Applicant will need to make an application to drill, and who must be notified when drilling commences. As already referred to, the traffic light system does not prevent a problem from occurring; it aims to prevent a problem from becoming large. The seismic array is intended to be very sensitive, and can detect movement and vibration from passing traffic, and farm machinery. The local gun club registers on the sensors, during background data gathering in November 2013 (ES para 73). If, during injection of fracking fluid, seismic activity exceeds $1.5M_L$ (ES paras 95-97) the injection of fluid will cease. Clearly, this is reactive, not preventive.

3.9.5 Recent research has indicated that induced quakes create less shaking, though they may be felt as much (67). This has led the authors of the referenced paper to suggest that a ten kilometre exclusion zone should be implemented in order to prevent people being disturbed by the effects from the operations. An exclusion zone on that size would not be possible for this project.

3.9.6 There was an earth tremor in the near vicinity when Cuadrilla was drilling at another site in the region in 2011 (68;69). This was attributed by the press and public to the Cuadrilla work.

3.9.7 The ES considers the assessment of fracking/drilling activities over many years, and suggests that the tremors were coincidental, as there have not been any reported incidents elsewhere across the globe which may be attributable to fracking/ drilling. Deep drilling has taken place for many years for other reasons; fracking has become a controversial issue with some members of the public due to publicity regarding methane in water, as well as earth tremors, and therefore considered by many to be an undesirable activity.

3.9.8 The ES refers to the seismic array which will be installed to monitor earth movements during the drilling and hydraulic fracturing stages. Drilling is needed to reach the deep rocks, and install the triple layer well casings, through which the fracking fluid will eventually be pumped under pressure to force the rocks apart and release the methane. The seismic array covers a 5km area with the drill rig at the centre. The array will monitor in real time, and enable the operators to have an understanding both of the impact of what is happening at any given time, but also the vulnerabilities of the ground in the area. The operator has developed a traffic light system which refers to the monitored activity, in order to suspend activity if it is detected that certain limits are being surpassed. The ES refers to such real time monitoring as mitigation, however it could more appropriately be

classified as an operational control. The seismic array will measure changes in activity, not prevent it from occurring.

3.9.9 The ES makes reference to work which has been undertaken by the Royal Society of Engineers which refutes the idea that drilling causes seismic activity. This has been undertaken in conjunction with the British Geological Society. A recent publication (70) on drilling, fracking and deep injection concluded that many seismic events which are attributable to these activities have been missed because of an absence of monitoring devices; they have not been installed by operators, hence only larger seismic events have registered on national monitoring equipment. Furthermore, the conclusion is that deep injections have a direct action on fault lines, making movement more likely. The project relies on the traffic light system to prevent too much movement from occurring. However if a faults slip, it cannot be returned to place, and a new pathway for contaminants may be created (see hydrogeology discussion section 3.6).

3.9.10 It should be pointed out that this new publication is too recent for the ES to have access to it or reference it prior to the publication of the ES. That notwithstanding, this requires further discussion as a breach of the deeper faults has implications for groundwater and aquifer protection. The ES acknowledges the impact which the speed and volume of fracking liquid can have on the way in which the geology reacts. There is a great deal of reliance on the seismic array to indicate if there are any problems.

3.9.11 It should also be noted that the location has a relatively high level of seismic activity for the UK, with the nearby Craven Fault moving on a regular basis (71).

3.9.12 These findings suggested the need for further information on how Verdon's analysis (70) relates to conclusions in the ES concerning impacts on induced seismology associated with hydraulic fracturing.

3.9.13 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC seeks further specific clarification on emerging evidence that deep injections have a direct action on fault lines.

3.9.14 The ES section 12.8 notes the proposed gas storage project at the nearby abandoned salt mines at Preesall (situated approximately 12km north-west of the Site) and concludes that the potential cumulative seismic impact is negligible and therefore not significant. Although the salt (where storage would occur) is at depth, and not faulted, deep drilling with strings (to create and then access the gas storage) penetrate several geological layers, potentially passing through faulted rock. Seismic activity fracturing those well casings (should that project also go ahead) could lead to a major loss of gas containment. Whilst the ES concludes that there is unlikely to be a cumulative impact with this exploration stage project (see ES para 137), the compatibility of these two industries operating in the same area should be carefully considered.[13]

3.9.15 The seismic activity chapter does not consider impacts on salt/brine mining in the area and its containment. Historic salt mining has left a legacy in the area of unstable salt caverns that are known to collapse with surface impacts. The extent to which induced seismic activity could contribute to such collapses should be considered.

3.9.16 These findings suggested the need for further information on whether the Applicant has considered the implications of seismic activity on salt/brine mining activity in the area.

[13] In the interests of transparency we note that BCA prepared a Health Impact Assessment report of the Preesall Underground Gas Storage Facility, on behalf of Halite Energy Group (72).

3.9.17 Based on this reviews findings and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC seeks further specific clarification on this point.

3.9.18 The impact of seismic activity may impair the integrity of the well heads and strings associated with this project. There is the potential for loss of containment of gas, with an attendant potential for above ground accident, or below ground contamination of aquifers, or possibly both. The well should be designed and constructed to accommodate the environmental and geologic conditions in which it is situated, including temperatures and pressure exerted by formations.

3.9.19 There is evidence from consultation that people are concerned about the effects on their homes from induced seismic activity and long-term ground settling movement. This is causing anxiety. Whilst it may not be feasible to expect the project to baseline housing condition, consideration should be given as to how such concerns can be monitored.

3.9.20 The ES notes that fracture growth and seismic events caused by hydraulic fracturing will be monitored during the fracturing using microseismic arrays which can measure the magnitude and location of induced seismicity. The ES seismic activity chapter appears to lack a discussion of the relationship between fracture growth and the measurement of induced seismicity as a surrogate for this growth. The ES places great weight on this monitoring technique to control the extent of fracture growth (i.e. maintaining a safe distance from any fault or other discontinuity that could lead to a contamination pathway or significant induced seismic event).

3.9.21 The ES (Section12.9 para131) states that since the activity at Preese hall, seismic activity will be monitored, and pumping of fracturing fluid will be done at a slower rate than was the case at Preese Hall. They will assume (para150) that all the faults are critically stressed, and take 3.5$M_L$ as a maximum for induced problems. The ES states (para 174) that they will be reporting back to DECC on a daily basis. It would be pertinent to know that this system is working, through feedback from DECC.

3.9.22 These findings suggested the need for further information on the degree of accuracy to which the microseismic arrays measure the extent of hydraulic fractures, including clarification of the relationship between fracture growth and the measurement of induced seismicity as a surrogate for this growth.

3.9.23 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC seeks further specific clarification on this point.

## 3.10 Land Use

3.10.1 ES chapter 13 assesses land use impacts of the Project. The ES concludes that the farmer will be the only one to be affected by land take for the project, and that the land will be reinstated at the end of the project. The ES considers the impact to be short term and not significant. This is unlikely to be an issue that requires further assessment from the HIA perspective.

3.10.2 Lancashire has a green plan which will be used to inform the planning decision. The ES notes that some of the implementation of the plan, and its ability to provide protection for the local land, has been inconsistent, and measures which the Applicant will deploy with regards to offsetting visual intrusion, planting hedgerows, will help to enhance the area.

## 3.11 Landscape and Visual Amenity

3.11.1 ES chapter 14 assesses landscape and visual amenity impacts of the Project. It concludes that the scale of the Project and the temporary nature of the exploration works means that the effect on landscape features and landscape character will be not significant. However, due to the visually intrusive nature of some of the equipment that will be used during the first 2 to 2.5 years of the Project a significant effect on visual amenity is predicted.

3.11.2 There are eleven sites which have been evaluated from which the effect is considered to be significant. These include the camp site at Roseacre Wood farm, as well as from nine other sites, which impact public Rights of Way. In addition, Stanley Farm has been counted as one viewpoint, though 5 properties have been assessed as being significantly affected from this same point. This is of concern to health of the local population should they choose not to undertake outdoor activity such as walking, if the combination of noise and visual intrusion mean that they no longer wish to go out.

3.11.3 There is mounting empirical evidence that interacting with nature delivers measurable benefits to people (73). Viewing natural scenes have been shown to produce different physiological responses to viewing built scenes (74).

3.11.4 The ES recognises that there are several properties for which the level of visual intrusion is significant. Suggestions for improvement are for trees and hedges which are currently in the vicinity of the site to be allowed to grow in order to provide screening. It is noted that some of the existing hedgerows are not necessarily in good order. If this is to be adopted, it should be undertaken at an early stage.

3.11.5 Visual intrusion has been considered at a local level. There has been no evaluation of the impact on the wider landscape, from the Bowland Fells in the ES. The Bowland fells are a recreational area for the local people, and the site's surface infrastructure (including 53m high rig) could potentially be visible. The use of trees and hedgerows will not be sufficient to disguise this. It is noted that the methodology for the ES visual impact assessment was agreed with LCC's landscape architect, including a determination that the visual impact of the development on the wider landscape did not need to be investigated.

3.11.6 Based on this reviews findings and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC does not need to seek further specific clarification on this point.

3.11.7 The ES does not discuss whether or not the flares could have a convection effect in the atmosphere which may create condensation plumes. Such plumes could increase visual disturbance and introduce an industrial element into the rural landscape under certain weather conditions.

3.11.8 These findings suggested the need for further information on whether the flares will be associated with condensation plumes under certain weather conditions.

3.11.9 Based on this reviews findings and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC seeks further specific clarification on this point.

3.11.10 The 'tranquillity' of the rural environment is also important, particularly with respect to people's mental health. Tranquillity encompasses a lack of disturbance influences, notably noise and visual disturbance. The Civil Aviation Authority recently provided an overview of the current area and state of knowledge of tranquillity and tranquil spaces within the UK (75). 'Disruption of tranquillity' is mentioned in the WHO *Guidelines on Community Noise*

(see Table 3-4, last row). The impact of the Project on levels of tranquillity is an issue that could be explored further by the ES.

3.11.11 The ES landscape and visual chapter concludes that significant visual effects would arise as a result of the drilling rig (between 30 and 53m high), hydraulic fracturing rig and well services rig (up to 36m high) which would be in use for approximately two and half years. The ES considers that any mitigation in the form of offsite screening is not possible.

3.11.12 This significant impact is of potential concern for health, particularly if experienced in combination with other forms of disturbance (e.g. noise and night time lighting). The ES classifies the 2.5 years duration as temporary. This report notes that whilst temporary it is not short term.

3.11.13 The key points relating to visual impact from the health perspective are as follows:

- There are a few residential receptors that will have a very intrusive view.
- There is also the wider (but still local) population impact from the roads and rights of way. There is potential (but probably modest) for reduced physical activity.
- Links with other disturbance, e.g. noise and light could create a cumulative impact (inter thematic – as opposed to the ES focus on intra thematic cumulative impacts).
- The visual impact may also exacerbate perception effects due to the constant visual reminder.

## 3.12 Lighting

3.12.1 ES chapter 15 assesses lighting impacts of the Project. It concludes that due to the combination of relatively few sources of night time lighting at the Site, use of lighting during the Project is predicted to have a significant effect for all project activities without mitigation except for installation of the surface and buried arrays, construction, decommissioning and restoration. By implementing mitigation measures the chapter reports that the potential effects of lighting being directed towards windows of properties and the intensity of lighting used are not significant. The chapter states that these measures also help to reduce the magnitude of the skyglow and building luminance effects although there is a temporary residual significant effect which remains following mitigation.

3.12.2 Although the chapter on air emissions describes the use of the flare stacks as keeping the flames within the stack, it is possible that there is still a glow from this. Flare light is mentioned in the project's permit application (see Application Supporting Documents pdf page 65/129). The permitting application assesses the potential for light impacts from the enclosed flares as a low risk rating and does not carry the issue forward to the risk assessment management plan. The issue is not explicitly discussed in the ES lighting chapter, but would contribute to skyglow.

3.12.3 The ES acknowledges that the project is to be centred in a dark sky area, and as such any light which is to be introduced will be an increase on existing levels. The Applicant intends to adhere to good practice, ensuring that lights are focused downwards. It is noted that this would not be possible for skyglow from the flare stacks.

3.12.4 Although the Applicant has indicated that not all activities will take place all the time, they have also stated that the site will be staffed 24/7, and that this will require lighting for staff safety.

3.12.5 When the drill rig has been put into place the lighting which is on the rig will be at height, and visible from quite a distance, above any hedgerows which may have grown up.

3.12.6 The Applicant notes that planning applications which create light intrusion are contrary to the Blackpool Local Plan (76). Policy CS7 of the emerging Blackpool Local Plan states that: development will not be permitted that causes unacceptable effects by reason of visual intrusion, overlooking, shading, noise and light pollution or any other adverse local impact on local character or amenity. However, Fylde Borough Council, which has responsibility for oversight of lighting, seeks to control intrusive lighting at the planning stage.

3.12.7 When unused to overnight light, people can have disturbed sleep patterns. Although uncertainty remains, there is plausible epidemiological evidence that circadian rhythm disruption has a variety of adverse physiological effects (77). The sensitive receptors identified will have light from several sources: the security lighting at about ten feet in height; transient, intermittent intensive lighting from construction, and the longer term rig lighting, which will be at height and is likely to impact a greater number of receptors.

3.12.8 The drill rig, which needs to be lit at height, (53 meters) will be in use for twenty four hours per day and require lighting (Chapter 15, section 2, para 7, reinforced at 15.6.8 para 38). The ES acknowledges that this will be a major significant impact pre-mitigation (see ES table 15.9). The ES expects to offset this by good practice, and by responding to complaints rapidly. If drilling is to be a 24/7 operation, and as explained in earlier chapters once drilling commences it is difficult to stop, it will not be possible to extinguish the lights as they are there for safety reasons. The measures that can be implemented in response to complaints therefore need to be investigated further. Consideration could be given to offering to fit blackout blinds in the bedrooms facing the site of the homes where significant impacts are expected.

## 3.13 Resources and Waste

3.13.1 ES chapter 17 assesses resources and waste impacts of the Project. It concludes that the waste generated by the personnel on site, in the form of general waste from canteen and office areas will not result in a significant effect. This also applies to inert and non-hazardous waste. Likewise, the quantity of waste generated by the Project (construction, drilling, hydraulic fracturing, initial and extended flow testing and decommissioning) is reported not to result in a significant effect. The chapter states that this is because there is sufficient capacity to treat the waste generated by the Project. However the chapter concludes that, although there is sufficient capacity to treat flowback fluid it is still anticipated to result in a significant effect because at peak times it will utilise a major proportion of the available treatment capacity within 100 miles of the Site (based on radiation levels and physical treatment capacity). Measures proposed by the ES to mitigate this effect are being developed and these include:

- use of additional treatment capacity at facilities within northern England;
- investment in on site treatment to recycle flowback fluid for use in hydraulic fracturing and to reduce the quantity of waste generated; and
- regulating the quantity of flowback fluid generated at the Site to not exceed the available waste treatment capacity.

3.13.2 The application provides the general pre-construction description of how waste will be managed, and disposal. It does not make any reference to minimisation of consumption, re-use, circular economy, and re-deployment of equipment.

3.13.3 There is no description of resource minimisation. Electronics industries (seismic array, and computerised controls) and drilling industries (tungsten tipped drills and other specialist materials) operate in a competing market for rare earth metals. Careful use of these materials is necessary for longer term availability within the healthcare field, particularly titanium for heart valves, and tungsten for artificial joints, as direct impacts, as well as

competing resources for medical devices which have an increasingly sophisticated nature and greater reliance on electronics.

3.13.4 The application has not currently referenced the ability to treat, on site, the waste water arisings from the drilling. Such waste water may be mildly radioactive as a result of containing naturally occurring radioactive materials (NORM). Although it will be tankered from site for disposal as hazardous/radioactive waste and disposed of at an as yet un-named licenced hazardous waste site, there is insufficient detail on how it will be temporarily stored on site. Some of the waste will be tankered within a day. Within the ES resources and waste chapter there is no clarity on the number of vehicle movements which that would entail. Although vehicle movements are described in the ES transport chapter, it is not clear exactly how many relate to removal of flowback NORM material.

3.13.5 It is clear that waste from this activity will place additional demand on the landfill regime. The Applicant indicates that the percentage space to be occupied is around 1% for landfill. It is somewhat greater for radionuclides. The Low level Waste Repository (LLWR) at Sellafield is able to take waste with low radioactivity contamination (the site is not identified in the ES) but is seeking to change the classification of waste which they receive in, and to move to resource efficiency[14]. The LLWR is an important resource for acceptance of hospital-generated low level radioactive waste. The Director of Public Health for LCC may wish to seek reassurance that acceptance of health-facility created radioactive waste is not compromised by permitting of the fracking activity given the limitations on LLWR capacity.

3.13.6 The EIA scoping document refers to production of liquid hydrocarbons. This is an area of uncertainty for the project as the presence of oils can only be determined once the process is underway. There is potential for flowback fluid (with NORM) to be contaminated with oil. The project proposes to reuse the flowback water as fracking fluid, reducing the burden of water consumption from Town water. Neither the ES nor the wider permitting application documentation is explicit on the potential liquid hydrocarbons waste stream and its implications for other process (such as the reuse of flowback water as fracking fluid).

3.13.7 These findings suggested the need for further information on any implications for: the capacity of regional waste sites to accept medical waste (including radioactive medical waste); and the management/process implications of a potential liquid hydrocarbon (oil) waste stream.

3.13.8 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC should confirm with the regulator (EA) that this issue is being considered as part of the permitting process. The Director of Public Health for LCC should remain engaged with the process and information that emerges on this issue from the planning and permitting processes.

3.13.9 The treatment of flowback liquid has been identified by the Applicant as an issue which is considered to have an impact which is 'very substantial' and therefore significant. When the output is assessed with the potential for being cumulative with Preston New Road the quantity produced would be 68% of available capacity.

3.13.10 Table 17.91 (ch 17, page 526, source 78) appears to indicate that with average production of flowback fluid, the unidentified sites A and B would be over their acceptance capacity. This takes both Preston New Road and Roseacre Wood exploratory fracking sites into

[14] The LLWR is under pressure and have changed their acceptance criteria. They are currently re-evaluating the waste which they are holding. See http://bit.ly/1lT3Mnp

account. The Applicant states that care would be taken during operation not to lead to a capacity issue. The Director of Public Health for LCC may wish to seek greater clarity on the meaning of this, and reassurance that there will not be a build-up of radioactive waste which cannot be removed at a later stage.

3.13.11 The current application pertains to an exploratory phase only. If there is insufficient waste management capacity at this stage it is reasonable to inquire what would happen in the longer term if full shale gas extraction applications come forward, both at the two sites mentioned and elsewhere in the Region.

3.13.12 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC does not need to seek further specific clarification on where the flowback fluid will be disposed, but should remain engaged with the process and information that emerges on storage, treatment and disposal of flowback fluid from the planning and permitting processes.

3.13.13 ES table 17.97 (ch 17, page 532, source 78) notes there may be a need for disposal of equipment which has been radioactively contaminated with NORM. There is no indication as to whether this may be an isolated incident, or a regular occurrence, nor the size of equipment which may become contaminated. This also will have a bearing on capacity.

3.13.14 These findings suggested the need for further information on how much equipment which has been radioactively contaminated with NORM will need to be disposed.

3.13.15 Based on this reviews findings and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC should seek further specific clarification on this point, and should respond appropriately within his capacity as a consultee to the permitting process.

3.13.16 The ES notes that mitigation may include additional tank capacity onsite to store flowback fluids temporarily, the aim being to buffer capacity issues at treatment plants. In the ES there is no indication of a limit on such additional storage. The maximum onsite capacity should be determined in advance to ensure the site's surface spill containment capacity is appropriate in the event of worst case containment failure.

3.13.17 The permitting application (see Application Supporting Documents pdf page 90/129 section 5.5) states that:

*Flowback fluid shall be stored at the surface in enclosed steel containers on top of the well pad membrane within the perimeter fence line... The combined onsite storage capacity of individual flowback fluid tanks equates to approximately 3000m$^2$… The integrity of tanks and vessels is visually checked weekly and subject to annual thickness tests.*

3.13.18 In addition to the question of treatment capacity, the Director of Public Health for LCC may wish to ascertain how the Applicant will manage operations in time of adverse weather conditions, both from the possible need to store waste (or alternatively suspend activity) as well as safety in terms of tanker journeys in unfavourable conditions.

3.13.19 The Preston New Road ES raises the issue of suspension brine. The Roseacre Wood ES does not appear to have a similar discussion. The reason for this is unclear.

3.13.20 These findings suggested the need for further information on whether suspension brine is an issue at Roseacre Wood and if so how it will be disposed of.

3.13.21 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC seeks further specific clarification on this point.

## 3.14 Transport

3.14.1 ES chapter 18 assesses transport impacts of the Project. It concludes that by using standard criteria to assess the vehicle movements attributable to the Project the transport impacts will not result in a significant effect.

3.14.2 The PHE profile for Fylde shows that road injuries and deaths in Fylde are significantly worse than the England average. Any change caused by the Project that could affect road safety is therefore an important issue for the HIA.

3.14.3 In section 4 of the ES (which sets the context) section 4.6 considers access to the site:

- The preferred route for Heavy Goods Vehicles (HGVs) follows the existing public road network from Junction 4 of the M55 passing along the A585 (Kirkham Bypass), Salwick Road, Dagger Road, Inskip Road and Roseacre Road. This is termed the "Wharles Route".
- A variation follows the same route up to Inskip Road and then passing through the Ministry of Defence's (MoD) Defence High Frequency Communications Site (DHFCS) Inskip facility. This is termed the "DHFCS Inskip" route. This would have the benefit of allowing HGV traffic to bypass the village of Wharles.

3.14.4 ES section 18.4.3.1 paragraphs 25 and 26 acknowledge that the roads in the vicinity of the site are narrow. It does not equate this with driver delay resulting from decreased manoeuvrability, but rather infers that the roads are quiet, suggesting that if the strategic road network can cope with the increased traffic movements, then the quieter ones will also have capacity (see ES section 18.4.3.1).

3.14.5 The ES has indicated that it will be necessary to construct passing places. The widening of the transport routes (due to the narrow roads and sharp bends) requires section of hedgerows to be removed or lowered (see ES section 14.7.2). This would seem inconsistent with the mitigation measures for landscape intrusion which describe growing hedgerows higher.

3.14.6 The impact on the village of Wharles depends on the viability of the DHFCS Inskip route. This needs to be agreed with the MoD and could include its own hazards to project drivers due to the electric power lines. As noted previously, if high non-standard current or voltages are being used, consideration should be given both to electrical arcing causing electrocution and EMF occupational exposures.

3.14.7 There is a variability in the increase in traffic against the base line. Generally the further from the main roads the traffic movements are, the greater the percentage increase against background. During the fracking process when there is a need to tanker away flowback fluid, vehicle movements may be as many as 54 two-way vehicle movements per day (see ES section 18.7.4.1. para 170). Although this may be within the road networks technical capacity, this is not the same as there not being an impact on local road users.

3.14.8 At various stages of the project there is the need to bring in 40ft trailers e.g. for office space and work space (see ES section 4.7.1). The site visit left the impression that HGVs with such large loads would have difficulty safely negotiating the routes in proximity to the project site. It will be important that the Applicant demonstrates that the use of oversized vehicles on the route is feasible without compromising road safety (for existing roads

users, pedestrians or cyclists). The ES assessment of road safety considers historical accident data and the number of vehicles associated with the project (see ES section 18.7.1 para 112). No specific consideration seems to have been made of vehicle size or the nature of the road network (narrow with several sharp bends).

3.14.9 Although distant from the site surface infrastructure, the potential traffic impact at Clifton should not be overlooked (see ES chapter 18 para 105). It is acknowledged that the baseline monitoring shows a lot of existing LGV and HGV traffic (see ES table 18.105). Clifton village is residential with a playground accessed across the main road with no formal crossing point. The road capacity does not appear to be any greater in Clifton than elsewhere on the route (once off the A583). Clifton could be viewed as an already saturated location rather than one that is justifiable due to existing levels of traffic movements. The ES notes that accident rates for this stretch are higher than the route section closer to the site (though still assessed as low by the ES - see ES section 18.7.1 para 113). The ES accidents and safety assessment considers the ecological sensitivity of the area, but does not appear to consider human sensitivities. Pedestrian impacts (particularly children accessing the playground) may be a concern, particularly given that the project's operations include transport movements outside of normal work hours, including Saturday mornings.

3.14.10 ES Appendix R considers the relative merits of several options for access routes. None is without problems. There is some compromise to existing users, for example the roads do not easily accommodate passing of HGVs; there is cycle route along the road; and a school adjacent to the road.

3.14.11 Cycling and walking are activities which are to be encouraged, particularly to help prevent obesity and type II diabetes. The proposed routes have the potential to impact on these activities at the local level.

3.14.12 We suggest that the Director of Public Health for LCC seeks further clarification from both LCC and the Highways Agency that the proposed traffic flow (including vehicles sizes) will not lead to increased accidents along the proposed routes, nor a compromise to the use of these routes for cycling or walking.

3.14.13 The safe transport of hazardous/radioactive wastes including 50,450$m^3$ of flowback fluid waste with NORM to offsite treatment facilities appears not to be a topic covered by the ES under Public Health. Although such transport will be under permitting regimes, the potential health impacts from spillages or accidents are important. ES hydrogeology and ground gas chapter considers the potential for off-site road traffic accident resulting in spill of potentially contaminating materials. Off-site human health is considered a receptor with exposure via spillage onto public highways. The ES notes that HGV routes for site vehicles will be agreed with the relevant authorities, considering the potential for accidents and selecting the most appropriate route. Furthermore that: competent haulage contractors, who are licensed waste carriers, as required under the IPPC permitting regime, will be appointed in accordance with the Applicant's HSSE Framework; vehicles will have spill kits and MSDS sheets; and the Applicant's 24 hour emergency response contractor will respond to any incident. Appendix K2 includes additional supporting assessment of transit issues, such as spills of potentially polluting material. The transport of similar wastes from Preston New Road site presents a cumulative impact. Although it is accepted that there are expected to be two different routes through Lancashire to the main highways (from RW and PNR respectively), the impact then becomes aggregated on the motorways. This impact has not been assessed. It is not required within the planning regime. However, an HIA can comment upon this, as it considers the impacts over time and at geographical locations which are not local to the proposed activity.

3.14.14 The limited capacity of identified treatment facilities to manage the flowback fluid from both sites is identified in the ES resources and waste chapter as a "very substantial significant impact"[15] (see paragraph 311 in section 17.7.10.2 of ES). The mitigation includes identifying alternative treatment facilities. This could extend road journeys for hazardous/radioactive waste. The ES transport assessment identifies that a significant proportion of HGV movements during the initial flow testing period are tanker movements associated with the removal of flowback fluid. The ES resources and waste chapter discusses volumes and treatment requirements for hazardous/radioactive wastes, it does not cover transport implications.

3.14.15 These findings suggested the need for further information on the transport of hazardous and radioactive wastes (including those with NORM) from the site to treatment facilities.

3.14.16 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC seeks further specific clarification on the locations and routes for hazardous and radioactive waste treatment. It is noted that hazardous loads are a familiar feature of the UK road network. Once the locations of relevant treatment facilities have been identified, the Director of Public Health for LCC could comment on the need for routing away from population centres and accident hotspots.

3.14.17 It is noted that the baseline data was collected during October. The attraction of the Blackpool illuminations can increase traffic at this time of year. However, during the summer months standing traffic can become a feature of roads leading into Blackpool. If this occurs, the contribution of the HGVs to the poor air quality experienced in Blackpool and Kirkham would be increased.

3.14.18 These findings suggested the need for further information on whether the assessment has included seasonal road congestion.

3.14.19 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC seeks further specific clarification on this point.

## 3.15 Water Resources

3.15.1 ES chapter 19 assesses water resource impacts of the Project. It notes that the location for this exploration well pad has been selected to avoid areas identified by the Environment Agency as being at risk from flooding. The chapter reports that the well pad and drainage system has been designed to retain any fluid or water that is spilt within the Site and therefore helps to manage any risks to water quality in the area. The chapter states that to avoid impacts on the availability of natural water resources in the vicinity of the Site all of the required water will be taken from the mains water network. The chapter reports that United Utilities have confirmed that they are able to supply the Site with the quantity of mains water required without having an adverse impact on other users subject to changes in supply engineering. Foul and waste water will be removed from the Site by tanker for disposal at an appropriate licensed waste water treatment works. The chapter concludes that the Project will not result in a significant effect.

[15] The ES resources and waste chapter defines 'Very Substantial Significant' as a severe permanent reduction in landfill void space capacity on a local and regional scale, or a need for large scale waste treatment facilities to protect against adverse environmental effects. This equates to >10% waste generation relative to local / regional capacity.

3.15.2 The risks of contamination of groundwater and surface water associated with the Project are presented in the Hydrogeology and Ground Gas Chapter.

3.15.3 At a time of uncertainty and climate change, it is difficult to evaluate opposing issues at the same time. The Applicant is required to demonstrate the ability to take operational water without compromising the quantity and quality of drinking water; to ensure that site operations do not contribute to flood risk; and to demonstrate resilience in the time of potential flood. Climate change uncertainty has been communicated by UK Climate Change Impact Programme (79).

3.15.4 The Applicant states that they will be using town water (i.e. water supplied via the mains to households, hospitals, businesses, and which has been treated by the water supply company, in this case United Utilities, to meet UK drinking water standard).

3.15.5 United Utilities have indicated that in order to supply the site they would need to install a new pipe from the existing asbestos supply pipe, and also a new supply valve, in order to maintain pressure to existing users. Other modifications would also be required to the pipework (Unspecified) (section 19.7.1.1 para 45).

3.15.6 It would be appropriate to ascertain that UU as supplier and the Environment Agency (EA) as regulator have confidence that the proposed level of usage will not compromise households in the event of hot weather and increased demand. In two summers recently contingency plans have been put in place for supplying water via stand pipes if demand outstrips supply. The effect would cover an area beyond the operational area of the project. The Applicant states that the area is not water stressed, being a recipient of UU's integrated supply strategy, where water can be moved from an area of availability to one of need through pipe connectivity.

3.15.7 United Utilities' letter confirming that there is sufficient supply specifically notes that for the Roseacre site the network will not support the projects highest flow rate scenario (see ES appendix S page S21).

3.15.8 These findings suggested the need for further information on the proposal's water demands in the event of hot weather, drought or other unusually high periods of increased demand.

3.15.9 Based on the findings of this review and taking into consideration comments made by the Health Advisory Group and organisations invited to attend its meetings for similar issues raised during the review of the Preston New Road ES, we suggest that the Director of Public Health for LCC confirms with the regulator (EA) that the Project's impact on public water capacity in the event of hot weather, drought or other unusually high periods of increased demand is being considered as part of the permitting process. Furthermore clarification is required of the implication of UU's disclosure that the network does not support the project's highest flow rate scenario. The Director of Public Health for LCC should remain engaged with the process and information that emerges on this issue from the planning and permitting processes.

3.15.10 Although the site is only a little above sea level, the bund which provides containment of rainwater prior to controlled discharge also provides protection during times of potential inundation. The emergency plan, when designed, needs to ensure the safety of workers on this site, such that in the event of a storm surge there is an appropriate evacuation plan in place.

# 4 Conclusion

4.1.1 This is a detailed ES for the level of proposed development. Overall the ES appears to have provided the information which would have been expected, though there are some areas which need clarification. The main queries are listed out below.

## 4.2 Clarifications sought

### General

*We suggest that the Director of Public Health for LCC:*

4.2.1 Seeks clarification that the monitoring framework requirements set through the planning and permitting processes will address not only the short-to-medium term impacts of disturbance and pollutants arising from the site to the local population, but also the potential for long-term (and potentially more widespread) legacy impacts on groundwater and ground gas. Such monitoring should be tied to an action plan with defined roles and responsibilities for notifying and responding to exceedances for the full period of the monitoring. We suggest that the Director of Public Health for LCC should remain engaged with the process and information that emerges on monitoring from the planning and permitting processes.

4.2.2 Requests that regulators collectively produce a document that summarises the application's adherence to the DECC Regulatory road map guidance (13); including the planning and permitting conditions and monitoring requirements that have been imposed at each step for the protection of public health.

4.2.3 Confirms when and what further information will be available regarding quantitative risk assessment (including unplanned events and reference to ½LFL[16]).

4.2.4 We suggest that the Director of Public Health for LCC should seek reassurance that any use of or changes to the MoD Inskip site is not associated with a public or occupational increased risks from electrocution or EMF exposure.

4.2.5 Seeks further detail on the influence on people's perception of safety associated with property values, amenity value of outdoor space and levels of physical activity.

4.2.6 Confirms how the proponent will ensure and demonstrate that all pollution will be as low as reasonably practical using BAT. This applies to air quality (including $PM_{10}$ and $PM_{2.5}$), noise, vibration, light and any other release from the activities on site or associated with the site.

4.2.7 Request clarification on the cumulative impacts inter (between) rather than intra (within) topics presented in the ES. For example: the cumulative radiological impact to the closest residential receptors from radiological emissions (notably radon) associated with flaring, water (NORM) and any solid waste stored onsite; or the cumulative impact of all sources of potential disturbance and nuisance to the closest residential receptors (including noise, dust, light, traffic etc …).

[16] Being outside the area where gas has dispersed from the source to a concentration of half its lower flammable limit (½LFL) is a recognised threshold of reasonable safety (14).

## Air quality

*We suggest that the Director of Public Health for LCC:*

4.2.8 Seeks clarification as to whether there will be periods of higher exposure to radon (e.g. during the 120 day flare period assumed by the radon modelling) than is suggested by the ES reporting the exposure levels as an annual effective dose. Notably whether peak levels will exceed 400 Bq/$m^3$ in any 24 hour period at any receptor (on or off site). [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

4.2.9 Request clarification of whether one or two flares have been included for the radon modelling. It would be useful for actual receptors and weather data to be used in the radon modelling. [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

4.2.10 Request additional modelling of the likely radon exposure levels during unplanned events (*e.g.* loss of gas containment at ground level) for occupational and residential receptor doses. For each radon modelling result (including those requested above), data in unit of µSv/year and Bq/$m^3$ would be useful. [This clarification is unlikely to change the overall conclusion in terms of public health, but would assist in resolving this as an issue for the HIA.]

4.2.11 Request information on what alternatives have been considered for the capture and the use of methane during the 90 day initial flow testing stage and clarify how the decision to flare has been reached.

## Noise

*We suggest that the Director of Public Health for LCC:*

4.2.12 Requests additional mitigation be incorporated into the Project to ensure that at all receptors noise levels attributable to the Project (notably well pad construction, drilling and hydraulic fracturing) neither exceed the WHO general health based threshold of 50/55 dB $L_{Aeq,\ 16hr}$ (48); nor the WHO night noise threshold of 40 dB $L_{night,\ outside}$ (47). This recommendation is aligned with the HIA objective of minimising health impacts, rather than meeting statutory or regulatory limits.

4.2.13 We suggest that the Director of Public Health for LCC requests regulatory authorities control the working hours and days for Project activities, particularly hydraulic fracturing. Consideration could be given to only operating the fracturing pumps during weekday daytime and ceasing activity during weekends and bank-holidays.

4.2.14 For noise impacts attributable to the Project which are justified on the basis of being of a similar decibel level to background noise, requests further reporting of the frequency spectrum and time-structure of such noise to evidence that it will not be clearly audible against background levels.

## Hydrogeology and ground gas

*We suggest that the Director of Public Health for LCC:*

4.2.15 Requests updates from the Environment Agency to be assured that:

- baseline data on methane in water is understood for the proposed operational area;
- emerging knowledge on fracture proliferation continues to inform monitoring requirements;
- the DPH is informed of any breach of regulation which may occur in the future should this application be granted; and

- monitoring regimes take account of long-term migrations and the potential deterioration of the well over time.

4.2.16 Seeks clarification of how, and for how long, the Applicant will monitor the project's effect on the permeability and mobility of surrounding geological strata and natural fractures to ground water. Confirming the hypothesis, advanced in the ES, that the Woodsfold fault creates a barrier to water movement between the ground water contamination of the application and the public water supply is particularly important. Sufficient information should be provided to satisfy the Director of Public Health for LCC that public water supply will not be contaminated directly or indirectly as a result of the Project, including long-term impacts.

4.2.17 Seeks clarification as to whether non-hazardous drilling mud will be used when drilling through faults, particularly the Mid-Elswick Graben Faults. Alternatives to drilling through this fault could be set out.

4.2.18 Requests further information on how the application will affect long-term low level gas permeation to the surface including permeation to the surface which may be distant to the proposed site. Estimates of potential surface concentrations and areas of effect would be helpful.

4.2.19 Seeks confirmation of what remediation action will be taken if a significant pathway, along a fault or other discontinuity, is established for gas to the surface.

4.2.20 Requests that regulators require an appropriate long-term monitoring plan post decommissioning / abandonment to ensure that the Project does not cause adverse legacy issues for air, ground or water contamination. Responsibility for monitoring should be clearly defined and set through condition, legal agreement and / or bond. The Director of Public Health for LCC should remain engaged with the monitoring information that emerges from the planning and permitting processes.

## Climate change

*We suggest that the Director of Public Health for LCC:*

4.2.21 Seeks further specific clarification on long-term post abandonment impacts to climate change both: as well integrity degrades, potentially creating a pathway for natural gas (notably methane) to the surface; and long-term slow permeation of un-extracted natural gas to the surface as a result of hydraulic fracturing mobilising such gases from their current geological layer. Climate change is an increasingly important determinant of health.

## Waste

*We suggest that the Director of Public Health for LCC:*

4.2.22 Confirms with the Environment Agency that the Project's impact on the capacity of regional waste sites to treatment/disposal of medical waste is being considered as part of the permitting process.

4.2.23 Seeks clarification regarding the presence, treatment and disposal or use of liquid hydrocarbons

4.2.24 Seeks clarification on how much equipment, which has been radioactively contaminated with NORM, will need to be disposed of and what implication this has for waste management capacity.

4.2.25 Seeks clarification on how suspension brine will be disposed of, as the ES does not describe this waste management pathway.

## Induced seismicity

*We suggest that the Director of Public Health for LCC:*

4.2.26 Considers Verdon (70) (amongst others), who, having looked at drilling, fracking and deep injection (for analogous processes), concludes that deep injections have a direct action on fault lines; and requests clarification of how this analysis relates to conclusions in the ES concerning impacts on induced seismology associated with hydraulic fracturing.

4.2.27 Requests clarification that the Applicant has considered the implications of induced seismic activity on salt/brine mining activity in the area.

4.2.28 Seeks supporting evidence on the degree of accuracy to which the microseismic arrays measure the extent of hydraulic fractures. Including clarification of the relationship between fracture growth and the measurement of induced seismicity as a surrogate for this growth.

## Visual impacts

*We suggest that the Director of Public Health for LCC:*

4.2.29 Seeks clarification on whether the flares will be associated with condensation plumes due to convection effect in the atmosphere under certain weather conditions. Any plume could increase visual disturbance and introduce an industrial element into the rural landscape.

## Transport

*We suggest that the Director of Public Health for LCC:*

4.2.30 Seeks clarification from both LCC and the Highways Agency that the proposed traffic flow (including consideration of vehicles sizes, percentage increases in movements and road suitability for large vehicles) will not lead to increased accidents along the proposed routes, nor a compromise to the use of these routes for cycling or walking.

4.2.31 Seeks clarification on the locations and routes for hazardous and radioactive waste treatment. It is noted that hazardous loads are a familiar feature of the UK road network. Once the locations of relevant treatment facilities have been identified, the Director of Public Health for LCC could comment on the need for routing away from population centres and accident hotspots.

4.2.32 Confirms that the traffic impacts (including air quality) of the proposals have considered seasonal road congestion, for example during the summer months standing traffic can become a feature of roads leading into Blackpool.

## Water resources

*We suggest that the Director of Public Health for LCC:*

4.2.33 Confirms with the Environment Agency that the Project's impact on public water capacity in the event of hot weather, drought or other unusually high periods of increased demand is being considered as part of the permitting process.

4.2.34 Seeks clarification on the implication of United Utilities' disclosure that the network does not support the Project's highest flow rate scenario for the Roseacre Wood site.

## 4.3 Additional questions arising from consideration of the IPPC application for Roseacre Wood

4.3.1 The questions listed below pertain to documents (other than the ES and its appendices) submitted in support of the three IPPC applications for this Project. The documents comprise: the Environment Agency forms which form the IPPC applications themselves; EA Permit Application; Non Technical Summary to the IPPC application; a group of documents referred to on the EA web site as 'Application Supporting Documents'; RSR Application forms; and RSR support Documents. These were all publically available on the Environment Agency Web site.

4.3.2 Non-technical summary IPPC applications Roseacre wood. Section 10.1 states 'extracted waste to be kept in skips and containers at the surface prior to removal.' We suggest that the Director of Public Health for LCC should clarify whether these skips will contain any material potentially contaminated with raw (extracted) oil withdrawn from the wells. If so, clarify how emissions of associated VOCs and PAHs will be prevented. A similar clarification should be sought to confirm how venting to atmosphere be prevented for any oily contamination of flowback liquid.

4.3.3 Non-technical summary IPPC applications Roseacre wood. Section 11.2 states 'emissions from the flare stack will be assessed.' We suggest that the Director of Public Health for LCC should clarify whether both of the two flare stacks associate with the project will be operating simultaneously. If appropriate confirmation should be sought that modelling of air emissions has taken into account potential emissions from both stakes.

4.3.4 Non-technical summary IPPC applications Roseacre wood. Section 2.4.4 states 'a range of air quality data shall be collected as part of the evaluation of the site.' We suggest that the Director of Public Health for LCC should clarify whether such monitoring will extend to locations at nearby homes (notably those in Roseacre, and at Orchard Old Farm) in order to provide pre-operational baseline data. If this is the case, clarification of the mechanism for making this information available to the residents and health professionals.

4.3.5 Non-technical summary IPPC applications Roseacre wood. Section 4 (non permitted activities) concerns 'storage and disposal of hazardous and non-hazardous wastes not directly associated with the permitted activities'. We suggest that the Director of Public Health for LCC should clarify the hazardous wastes that are being referred to, and if they are not directly associated with permitted activities, the justification for their presence.

4.3.6 Waste Management Plan. Permit. HSE-permit-INS-RW006. Table 1: flowback fluid states that the flowback fluid is to be re-used wherever possible. However, it is to be stored as a non-hazardous waste. We suggest that the Director of Public Health for LCC should clarify how the flowback fluid (potentially contaminated with NORM and oily waste) will be transformed into being classified as reusable, such that it can be re-injected into the rock.

4.3.7 Waste Management Plan. Permit. HSE-permit-INS-RW006. Table 1: natural gas. It is noted that the natural gas is highly explosive. We suggest that the Director of Public Health for LCC should clarify the ½FL associated with the activity, and how this may impact the local population. This includes road users as well as residents. Consideration should also be given to the potential for impact on planes using the local airport (vertical impact distance of a worst case explosion risk).

4.3.8 Waste Management Plan. Permit. HSE-permit-INS-RW006. Section 2.2.2 states 'use of LTOBM to be used only after setting of casing to protect the Sherwood Sandstone'. It is noted that lower layers of rock (millstone grit and colleyhurst sandstones) are also aquifers, as acknowledged in Arup's scoping document for Cuadrilla's Grange Hall site, in

addition to many geological reports. We suggest that the Director of Public Health for LCC should clarify the protection mechanism that the Applicant intends to put in place for these lower water bearing strata. Such strata may potentially be required for drinking water in the future, irrespective of solute level.

4.3.9 Waste Management Plan. Permit. HSE-permit-INS-RW006. Section 2.3 Hydraulic fracturing states 'as a contingency, hydrochloric acid may be used'. We suggest that the Director of Public Health for LCC should clarify in what way the presence of the acid in the fracturing fluid changes the chemical behaviour of the rocks when fractured, in particular in the presence of changing salinity.

4.3.10 Waste Management Plan. Permit. HSE-permit-INS-RW006. Section 2.3.1 Precautionary approach to deep groundwater receptors associates the carboniferous Millstone grit with the input of a pollutant. It is noted that water migrates laterally as well as vertically, and changes in character as it does so. We suggest that the Director of Public Health for LCC should clarify how lateral flow will be protected in a north south direction. Furthermore as the flowback negative pressure is created to bring out gas, what mechanism will prevents reverse flow of groundwater.

4.3.11 Waste Management Plan. Permit. HSE-permit-INS-RW006. Section 2.5 Well abandonment. We suggest that the Director of Public Health for LCC should clarify: who takes responsibility for post abandonment monitoring; what monitoring is expected to be carried out; and over what time frame will this be implemented.

4.3.12 Waste Management Plan. Permit. HSE-permit-INS-RW006. Section 8.3 notes that if any oil is visually identified in the flowback fluid, it will be analysed, this may include Btex, PAHs, GRO and DRO. It is noted that there does not appear to be any mitigation for liquid hydrocarbons. We suggest that the Director of Public Health for LCC should clarify how any liquid hydrocarbons will be stored, separated, treated and removed from NORM and flowback fluid.

4.3.13 Waste Management Plan. Permit. HSE-permit-INS-RW006. Section 8.4 Air quality. We suggest that the Director of Public Health for LCC should clarify if it is possible for drilling to take place at the same time as flaring. If so, clarify the cumulative impact of products of combustion plus particulates from drilling plus vehicular movements for waste removal. Modelling of this scenario could use ADMS. Furthermore, as the region has had multiple exceedances of ozone, as would be expected at a coastal area, clarification could be sought on how NOx emissions factor into the daily ozone chemical changes.

4.3.14 Waste Management Plan. Permit. HSE-permit-INS-RW006. Table 5 Air quality monitoring parameters and methods. It is noted that diffusion tube monitoring appears to be being used for VOCs, BTex, and total petroleum hydrocarbons. We suggest that the Director of Public Health for LCC should clarify if this approach has been determined to be BAT, as these are pollutants which do not normally remain resident in diffusion tubes.

4.3.15 Waste Management Plan. Permit. HSE-permit-INS-RW006. Section 8.6 Noise and vibration. It is noted that the section appears to refer to the noise from one flare. The technical data for the flaring appears to give the data for the flare, as 45db at 25 meters from the flare. We suggest that the Director of Public Health for LCC should clarify what noise modelling has been undertaken for the flare(s).

4.3.16 Waste Management Plan. Permit. HSE-permit-INS-RW006. Section 8.6 Noise and vibration. It is noted that this section does not seem to consider impacts from drilling and or pumping as part of the noise assessments. These appear to be potentially cumulative impacts, with the flare also possible as a contributor. We suggest that the Director of Public Health for LCC should clarify what cumulative noise impact modelling has been undertaken for these

sources, with particular note of the receptors at Roseacre Farm, Old Orchard farm as sensitive locations.

4.3.17 Waste Management Plan. Permit. HSE-permit-INS-RW006. Section 8.6 Noise and vibration. We suggest that the Director of Public Health for LCC should clarify whether the noise modelling takes into account the fact that drilling of the wells is in subtly different locations on the well pad, and may therefore be closer to some receptors at some time during the process.

4.3.18 Waste Management Plan. Permit. HSE-permit-INS-RW006. Section 8.6 Noise and vibration. We suggest that the Director of Public Health for LCC should clarify how the applicant intends to respond regarding noise monitoring if there are complaints regarding noise from local receptors.

4.3.19 Permit. HSE-permit-INS-RW011. Drawing, hazardous waste management site. We suggest that the Director of Public Health for LCC should clarify if the site will be a hazardous waste management site. If yes, clarification of which waste has been determined to be hazardous, as opposed to being radioactive. Furthermore as it is noted that there are surface waters very close to the well pad and also just below ground water, we suggest that the Director of Public Health for LCC should clarify if the hazardous materials could cause problems in surface water.

4.3.20 Absence of information. We suggest that the Director of Public Health for LCC should clarify the effects and locations of dust, noise and vibration from the installation of the seismic array, as this does not appear in the evaluation. Consideration of the total cumulative impacts (from all potential sources of disturbance and nuisance) on local receptors between the seismic array (the subject of a separate planning application) and the current application should be explicit.

# 5 List of references

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