IGEM
Institution of
Gas Engineers & Managers

IGEM/G/101
Communication 1766

Onshore Natural Gas extraction and route to use

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SECTION 1 : INTRODUCTION

1.1 This Guidance is part of a series of Institution of Gas Engineers and Managers (IGEM) publications, for all sectors of the gas industry providing practical guidance to support the Borehole Sites and Operations Regulations (BSOR), Offshore Installations and Wells (Design and Construction, etc) Regulations, Gas Safety (Management) Regulations (GS(M)R), and the Pipelines Safety Regulations (PSR). It has been drafted by an IGEM Working Group, which included representatives of the Department of Energy and Climate Change (DECC), gas extraction and gas monitoring companies and independent consultants, appointed by IGEM's Gas Transmission and Distribution Committee, and has been approved by IGEM's Technical Co-ordinating Committee on behalf of IGEM's Council.

1.2 This Guidance is the basis for good practice for the industry, including but not limited to:

- Gas exploration and production companies
- Gas transmission and storage companies
- Local Authorities
- Gas exploration and production companies
- Gas transmission and storage companies
- Local Authorities
- The Health and Safety Executive (HSE)
- Environmental Agency.

1.3 This Guidance has been prepared in the light of exploration for Shale gas in the UK.

1.4 In view of the increased governmental and industry involvement in the exploration and exploitation of unconventional gas over the next few years there will be revised and new advice being issued by DECC and the Environmental Agencies, therefore the latest information should be accessed by referencing the relevant government websites.

1.5 This Guidance makes use of the term "must":

- the term "must" identifies a requirement by law in UK at the time of publication.

Such terms may have different meanings when used in legislation, or Health and Safety Executive (HSE) Approved Codes of Practice (ACoPs) or guidance, and reference needs to be made to such statutory legislation or official guidance for information on legal obligations.

1.6 It is now widely accepted that the majority of accidents in industry generally are in some measure attributable to human as well as technical factors in the sense that actions by people initiated or contributed to the accidents, or people might have acted in a more appropriate manner to avert them.

It is therefore necessary to give proper consideration to the management of these human factors and the control of risk. To assist in this, it is recommended that due regard be paid to HSG48 and HSG65.

1.7 Requests for interpretation of this Guidance in relation to matters within its scope, but not precisely covered by the current text, should be addressed to Technical Services, IGEM, IGEM House, High Street, Kegworth, Derbyshire, DE74 2DA. Such requests will be submitted to the relevant Committee. Any advice given by or on behalf of IGEM does not imply acceptance of any liability, and does not relieve any party of their obligations.

1.8 This Guidance was published in August 2013.

SECTION 2 : SCOPE

2.1 This Guidance provides information on the current legislative framework that is in place which governs the drilling for exploration of oil and gas in the UK along with the health, safety and environmental considerations for the extraction, storage and transportation to the user or gas transporter, supplier or conveyor.

2.2 This Guidance provides local authorities and the public assurance that regulation and process controls are in place to ensure the safe extraction and supply of Natural Gas from on-shore wells to the point of use.

SECTION 3 : CONTEXT

3.1 EXTRACTING UNCONVENTIONAL GAS

Exploration of unconventional gases is at a very early stage in the UK. Recent technological advances mean that it could be economically viable for industry to explore the potential for extracting 'unconventional' gas from the following sources (see Figure 1):

- shale
- coal bed or coal seams.

Using the following processes:

- shale gas extraction
- coal bed methane extraction.

3.2 UNCONVENTIONAL GASES AND EXTRACTION METHODS

The composition of unconventional gases depends on their source. Shale gas and coal bed gas are predominately methane like conventional natural gas.

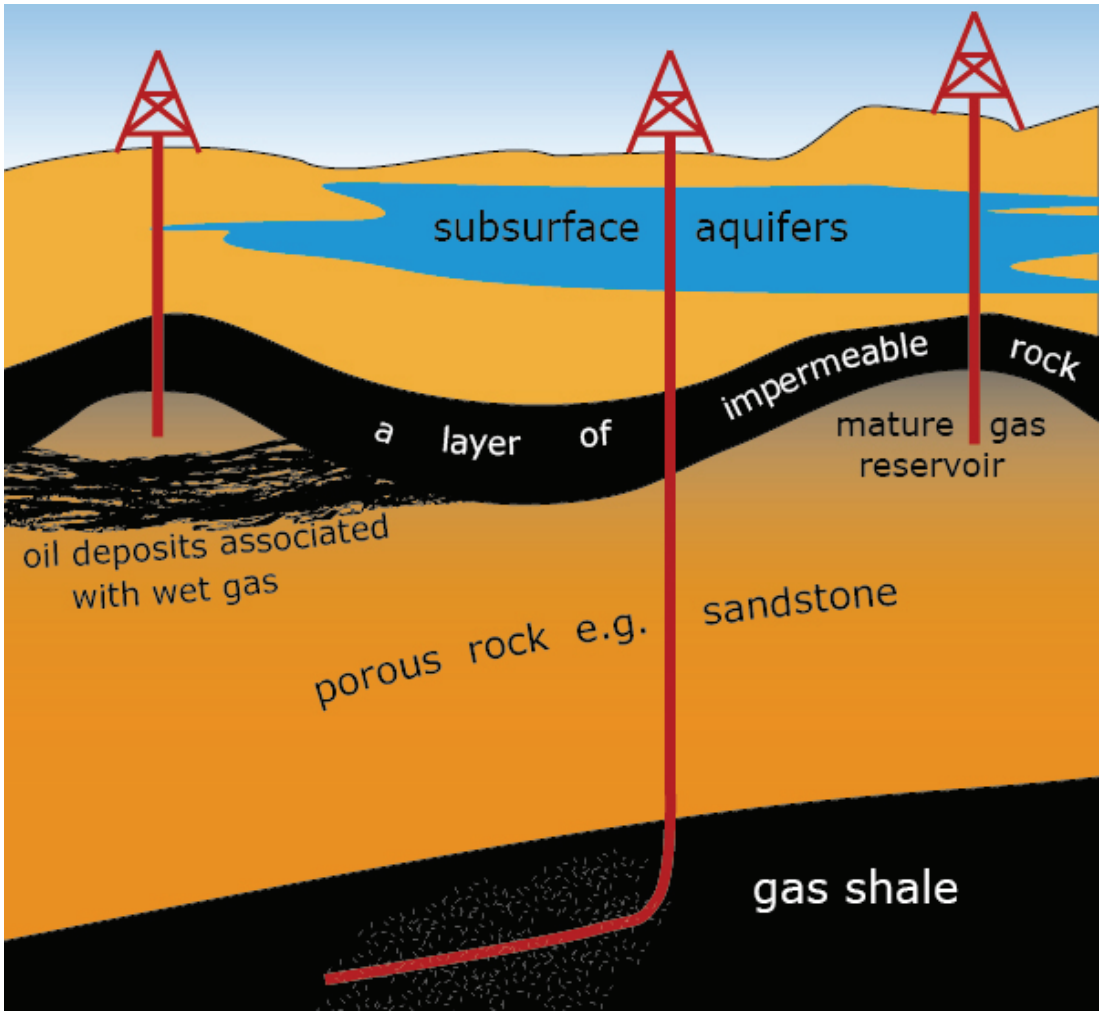
'Unconventional' refers to their source, that is, in Shale or Coal Bed which have not traditionally been exploited for gas production.

3.2.1 Shale gas

Shale was originally mud that has over millions of years been compacted and hardened into a fine-grained, sedimentary rock composed of clay minerals and tiny fragments of other minerals, especially quartz and calcite. Shale gas extraction involves extraction of the natural gas held in fractures, pore spaces and adsorbed on to the organic material of shale.

3.2.2 Coal Bed Methane (CBM)

Coal is a combustible black or brownish-black sedimentary rock normally occurring in rock strata in layers or veins called coal beds or coal seams. These are often referred to as CBM and are different to typical sandstone or other conventional gas reservoirs, as the methane is held within the coal by a process called adsorption. CBM extraction works by releasing pressure in coal seams.



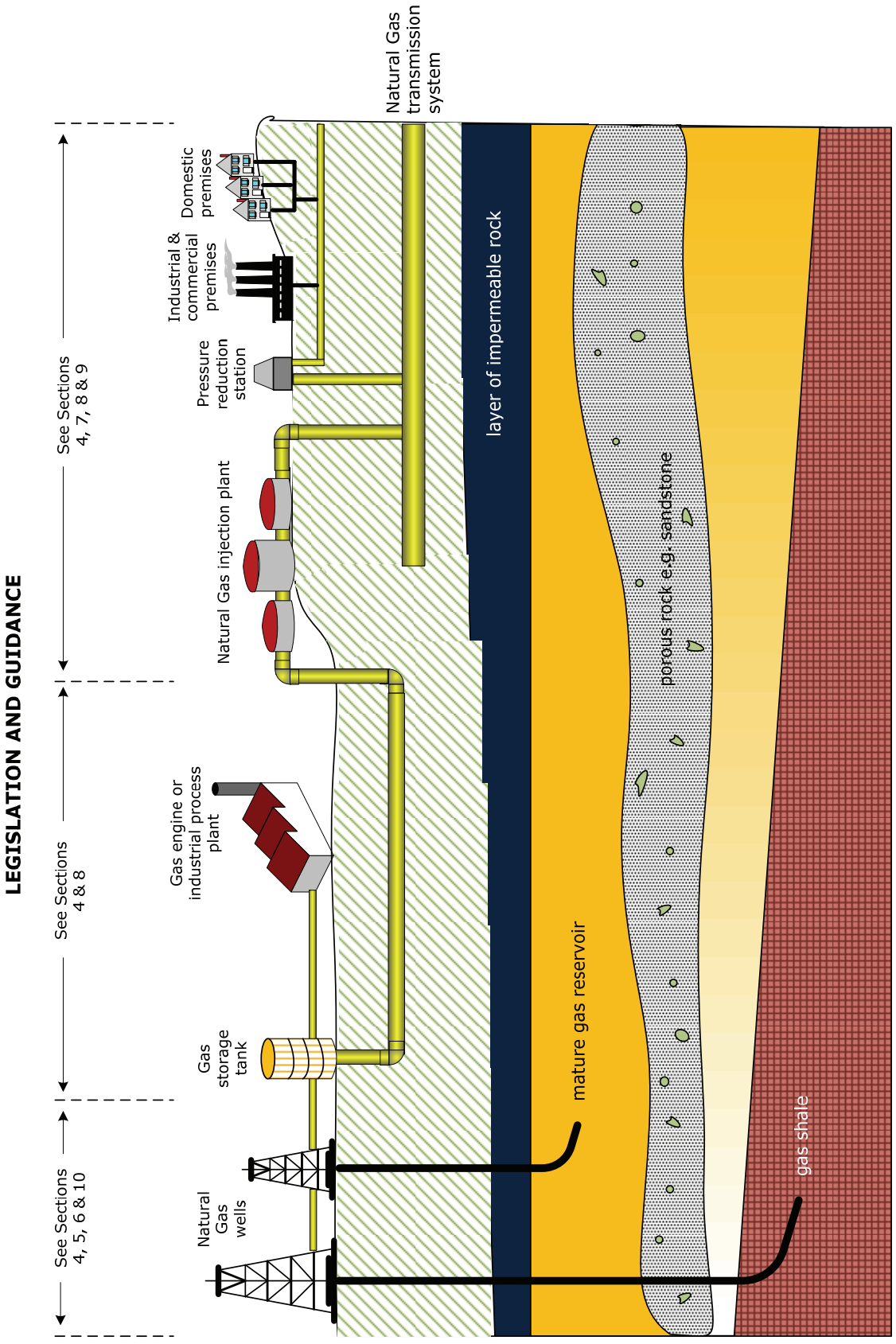
Note: From left to right - an associated conventional well, a shale well, a non-associated conventional well.

FIGURE 1 - SCHEMATIC GEOLOGY OF NATURAL GAS RESOURCES

3.3 STORAGE, TRANSMISSION, DISTRIBUTION AND USE OF NATURAL GAS

3.3.1 Natural Gas has been used throughout the UK since the 1960's. During this time, extensive research and development and experience has been gained which has enabled industry to be produced to describe the requirements for safely storing, transmitting, distributing and using Natural Gas. Much of this written guidance has been vested in IGEM and since the breakup of the industry in 1986 signalled by the Gas Act, the Institution has continued to review and revise the original guidance and write new documents with the support of industry. This has resulted in Standards that offer assurance to those who design, construct and use the Natural Gas system and it has resulted in a secure and safe supply of energy to homes and businesses across the UK.

Note: The range of legislation and guidance across the industry from extraction of the Natural Gas to its use is depicted in Figure 2.



Note: All these processes come under existing UK Legislation and Guidance through HSE, IGEM Standards and relevant industry bodies.

FIGURE 2 - SCHEMATIC SHOWING NATURAL GAS EXTRACTION TO POINT-OF-USE

SECTION 4 : LEGAL AND ALLIED CONSIDERATIONS

4.1 GENERAL

4.1.1 This Guidance is set out against a background of legislation in force in UK at the time of publication. The devolution of power to the Scottish, Welsh and Northern Ireland Assemblies means that there may be variations to the legislation described below for each of them and consideration of their particular requirements must be made. Similar considerations are likely to apply in other countries where reference to appropriate national legislation is necessary.

4.1.2 All relevant legislation must be applied and relevant Approved Codes of Practice (ACoPs), official Guidance and referenced codes, standards, etc. will be taken into account.

Note 1: The Department of Energy and Climate Change (DECC) provide up to date information on their website https://www.gov.uk/government/organisations/department-of-energy-climate-change.

Note 2: Appendix 2 is relevant in this respect.

Where British Standards, etc. are quoted, equivalent national or international standards, etc. equally may be appropriate.

4.1.3 Health and safety legislation must be observed, especially those requirements which are concerned with the duties of Employers, not only to their own employees, but also to members of the public who may be affected.

4.1.4 Unless otherwise stated, the current editions of legislation and standards apply.

4.1.5 In the absence of specific legislation, it is essential that installations are designed, constructed, installed, operated and maintained so as to be safe.

4.1.6 The legislation appropriate to any installation will depend largely upon its location. Advice will need to be sought from the relevant Authorities.

4.1.7 The primary responsibility for compliance with legal duties rests with the Employer. The fact that certain employees, for example 'responsible engineers', are allowed to exercise their professional judgement does not allow Employers to abrogate their primary responsibilities. Employers must:

- have done everything to ensure, so far as is reasonably practicable, that there are no better protective measures that can be taken other than relying on the exercise of professional judgement by people in roles that are expected to exercise that professional judgement
- have done everything to ensure, so far as is reasonably practicable, that people in roles that are expected to exercise professional judgement have the skills, training, experience and personal qualities necessary for the proper exercise of their professional judgement
- have systems and procedures in place to ensure that the exercise of professional judgement is subject to appropriate monitoring and review
- not require people in roles that are expected to exercise professional judgement to undertake tasks which would necessitate the exercise of professional judgement that is not within their competence. There should be written procedures defining the extent to which people in such roles can exercise professional judgement. When people in roles that are expected to exercise professional judgement are asked to undertake tasks which deviate from this they should refer the matter for higher review.

4.1.8 Safety Case duty holders are required to put in place a competence assurance system that includes competence standards, assessment and reassessment. The HSE also requires duty holders to link safety critical activities, work roles and responsibilities with a comprehensive management system.

4.2 PRIMARY LEGISLATION

The Primary Legislation that applies to the gas industry includes:

- Gas Act
- Environmental Act
- Environmental Assessment (Scotland) Act
- Environmental Protection Act
- Health and Safety at Work Act
- Oil and Pipelines Act
- Town and Country Planning Act
- Town and Country Planning (Scotland) Act
- Traffic Management Act.

4.3 SECONDARY LEGISLATION

4.3.1 Borehole Sites and Operations Regulations (BSOR)

BSOR impose requirements, not covered by other legislation, of the European Directive on Boreholes (92/91/EEC) concerning the minimum requirements for improving health and safety of workers in the mineral extracting industries through drilling. For oil and gas borehole sites including shale gas, notification to HSE is required for all drilling operations, abandonment operations, any operation which would make a significant alteration to the well and any operation that would involve a risk of fluids (including gas) from the well or reservoir. In addition, there are two other requirements unrelated to the Directive. These are:

- Operators are required to give notice of drilling operations and in some cases subsequent abandonment of the borehole
- Operators are required to give notice of prospect drilling operations to meet a requirement of the Mines and Quarries Directive 92/104/EEC.

Note: Further guidance is available from HSL72.

4.3.2 Construction (Design and Management) Regulations (CDM)

CDM impose duties on designers, clients (and their agents), developers, CDM Coordinator and principal contractors. Not all the regulations apply to all construction projects. Further information is given in HSL144. For a notifiable project (as defined in CDM) the CDM Coordinator must notify HSE before construction work commences. Construction includes the alterations, repair redecoration, maintenance, decommissioning or demolition of a structure.

4.3.3 Control of Major Accident Hazard Regulations (COMAH)

The COMAH Regulations implement the Seveso II Directive except for the land-use planning requirements which are implemented by changes to planning legislation. They replaced the Control of Industrial Major Accident Hazards Regulations 1984 (CIMAH) and came into force on 1st April 1999. The Regulations are amended from 30 June 2005 to reflect changes to Seveso II.

Information on various aspects of the COMAH regime is also available on the following web sites:

- Scottish Environment Protection Agency
- The Environment Agency for England and Wales.

Their main aim of COMAH is to prevent and mitigate the effects of those major accidents involving dangerous substances, such as chlorine, liquefied petroleum gas, explosives and arsenic pentoxide which can cause serious damage/harm to people and/or the environment. The COMAH Regulations treat risks to the environment as seriously as those to people.

The main effect of the COMAH (Amendment) Regulations in 2005 is to broaden the scope COMAH through changes to Parts 2 and 3 of Schedule 1. These include:

- the addition of new named substances
- changes to some existing named substances and generic categories of substance, including revised qualifying quantities;
- changes to the aggregation rule where several dangerous substances may be present; and
- a broadening of scope at mines quarries, boreholes and landfill sites.

COMAH does not apply to borehole sites where a mineral, including natural gas, is extracted through the borehole, except where the site includes oil and gas reception (see COMAH Regulation 3(3)(c.) and paragraph 105 of the Guidance on COMAH).

The Competent Authority (CA) charges for work it undertakes on COMAH. Charges are made on an actuals basis i.e. the recovery of the full costs of the time spent by the CA in carrying out COMAH-related activities for a particular establishment.

Note: Further guidance is available from HSL111 and HSG191

4.3.4 Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)

These Regulations incorporate:

- ATEX Directive 94/9/EC (ATEX 95) – Safety of Apparatus
- ATEX Directive 99/92/EC (137A) – Safety of Installation
- Chemical Agents Directive (CAD) 98/24/EC.

DSEAR are concerned with protection against risks from fire, explosion and similar events arising from dangerous substances used or present in the workplace. DSEAR require that risks from dangerous substances are assessed, eliminated or reduced. They contain specific requirements to be applied where an explosive atmosphere may be present and require the provision of arrangements to deal with accidents, emergencies etc. and provision of information, training and use of dangerous substances. DSEAR also require the identification of pipelines and containers containing hazardous substances.

The following publications contain details of DSEAR and their application:

- HSL134
- HSL135
- HSL136
- HSL137
- HSL138
- INDG370.

4.3.5 Gas Safety (Management) Regulations (GS(M)R)

These Regulations are intended to cover the transport of NG to the public. They do not cover gases such as LPG, coke oven gases etc (see HSL80 Regulation 2(1)).
Regulation 8 of GS(M)R places an obligation on GTs/gas conveyors not to convey gas in a network unless the gas conforms with the requirements of Part I of Schedule 3 of the Regulations (include a stenching agent) except that this paragraph shall not apply where the gas is at a pressure above 7 bar.

GS(M)R (Regulations 7(4); 7(5) and 7(10)) place specific duties on GTs/gas conveyors, or their emergency service providers (ESPs), for dealing with gas escapes from pipes on their networks. Their primary duty is to make the situation safe. They are responsible not only for dealing with escapes from their own pipes, but also for dealing with escapes from gas fittings supplied with gas from pipes on their network. In GS(M)R, the term "gas escapes" includes escapes or emissions of CO from a gas fitting.

4.3.6 Management of Health and Safety at Work Regulations (MHSWR)

MHSWR impose a duty on employers and the self-employed to make assessments of risks to the health and safety of employees, and non-employees affected by their work. They also require effective planning and review of protective measures.

Note: Further guidance is available from HSL21.

4.3.7 Offshore Installations and Wells (Design and Construction, etc) Regulations

These Regulations cover the requirements for the safety of wells both onshore and offshore. The main duties are:

- to ensure that a well is designed, modified, commissioned, constructed, equipped, operated, maintained, suspended and abandoned so that risks from it are as low as is reasonably practicable
- to conduct an assessment of conditions below ground before starting a well
- to ensure that the design and construction of a well satisfactorily address its subsequent suspension and abandonment
- to ensure that before the design of a well is started or adopted, a well examination scheme is in place for ensuring that the well is designed and constructed so that so far as is reasonably practicable there can be no unplanned escape of fluids, and that the risks to people's health and safety are as low as is reasonably practicable
- to provide regular reports of well operations activity to HSE
- to promote competence in those who carry out well operations by ensuring they receive appropriate information, instruction, training and supervision.

4.3.8 Pipelines Safety Regulations (PSR)

PSR provides a means of securing pipeline integrity by ensuring that a pipeline is designed, constructed and operated safely. They apply to all Network pipes operated by a GT. Installations can vary in size and complexity, and installation designers need to give due consideration to the operating pressure (OP) and required gas flows.

Note: HSL81 provides an ACoP and guidance and HSL82 provides guidance on PSR.

In particular, PSR require that the operator ensures no fluid is conveyed in a pipeline unless the pipeline has been designed so that, as far as is reasonably practicable, examination and maintenance may be carried out safely. PSR also require that the operator ensures that a pipeline is maintained in an efficient state, in efficient order and in good repair.

Under the Pipelines Safety Regulations (PSR), any person operating a gas pipeline at gauge pressures exceeding 7 bar has additional requirements imposed on them with regard to emergencies such as loss of integrity.

4.3.9 Pressure Systems Safety Regulations (PSSR)

PSSR impose duties on designers, importers, suppliers, installers and user or owners to ensure that pressure systems do not give rise to danger. This is done by the correct design, installation and maintenance, provision of information, operation within safe operating limits and, where applicable, examination in accordance with a written scheme of examination drawn up or approved by a competent person (as defined by PSSR).

Relevant fluids for the purpose of this document would be natural gas at a pressure greater than 0.5 bar above atmospheric pressure. A pressure system would include bulk storage tanks, pressure vessels, pipelines and protective devices. Once the pressure in the pipework drops below 0.5 bar, and the user/owner can show clear evidence that the system does not contain, and is not liable to contain, a relevant fluid under foreseeable operating conditions, then that part of the system is no longer covered by PSSR. This is likely to be the case after the pressure relief valve associated with a pressure reducing valve which takes the pressure to below 0.5 bar, for example at the entry to a building.

Note the special requirements placed on protective devices in such systems (see para 110b of HSL122). PSSR also apply to pipelines and their protective devices in which the pressure exceeds 2 bar (see Sch 1 part 1 item 5 of HSL122).

Note: More information is available in HSL122 and some information is presented in the HSE free leaflets INDG261 and INDG178.

4.3.10 Provision and Use of Work Equipment Regulations (PUWER)

PUWER place duties on employers in relation to selection, suitability, maintenance, inspection, installation, instruction and training, prevention of danger and control of equipment.

Note: More information on PUWER can be found in HSL22. Free leaflets include INDG291 and INDG229.

The term 'work equipment' includes all fixed plant and machinery as well as portable tools for use at work. This includes gas/plant/cable detection equipment, digging tools, ladders, lifting equipment and hand tools.

4.3.11 **Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)**

RIDDOR require employers, self employed people or those in control of work premises to report certain work related accidents, diseases and dangerous occurrences.

Other people have duties to report certain gas incidents which may not appear to be work related:

- death or major injury arising out of the distribution, filling, import or supply of NG or LPG should be reported by the conveyor for NG and the filler, importer or supplier for LPG
- dangerous gas fittings (as defined in RIDDOR) should be reported by a "member of a class of persons".

Note: Further information may be sought from IGE/GL/8 Reporting and investigation of gas related incidents.

RIDDOR specifies reportable incidents in relation to a well. These are found in Schedule 2 paragraph 13. The person responsible for reporting well incidents can be found in Table 1 of the Guide to RIDDOR 1995.

Major injuries, death and dangerous occurrences must be notified immediately, for example by telephone, to the enforcing authority by the "responsible person" as defined by RIDDOR. Report can be made to the Incident Contact Centre:

- for fatal and major injuries only, telephone on 0845 300 9923 (opening hours Monday to Friday 8.30 am to 5 pm) and complete appropriate on-line form
- all other reports at HSE website www.hse.gov.uk.

Complete the appropriate online report form listed below.

- report of an injury
- report of a dangerous occurrence
- report of an injury offshore
- report of a dangerous occurrence offshore
- report of a case of disease
- report of flammable gas incident
- report of a dangerous gas fitting.

The form will then be submitted directly to the RIDDOR database and a copy issued to the person making the report.

On-line written reports are to be submitted within the required timescale (10 days, or 14 days for dangerous gas fittings). Other reports should be made as soon as practicable and within 10 days of the incident.

HSL73 contains detailed guidance on RIDDOR, including a full list of injuries etc. that need reporting.

4.4 ALLIED CONSIDERATIONS

Industry guidance includes:

- Well Integrity Guidelines

  The 'UK Onshore Shale Gas Well Guidelines' have been produced by UK Onshore Operators Group, a body representing the UK onshore oil and gas industry. They were written by the Well Integrity Workgroup which included oil company, drilling contractor and service company personnel with input from DECC and HSE. These guidelines were reviewed by and agreed with the UK Onshore Operators Group, a body representing the UK onshore oil and gas industry.

  The Guidelines are relevant to wells constructed under the exploration and appraisal stage at the time of publication in Great Britain for the extraction of naturally occurring hydrocarbons. The Guidelines contain what is believed to be good Industry practice and reference relevant legislation, standards and practices. The Guidelines concentrate on 'typical' wells and 'standard' operations.

  By adopting the practices presented in these guidelines, well-operators should be able to assure themselves of the integrity of their wells, and that they have complied with the requirements of the Offshore Installations and Wells (Design and Construction, etc) Regulations 1996.

  The guidelines are not intended to prevent any organisation from adopting an alternative approach to any aspect of well integrity management. However, the implications of adopting an alternative approach need to be considered in relation to the overall intent of well integrity management: to ensure so far as low as reasonably practicable there can be no unplanned escape of fluids from the well, and the risk to health and safety are as low as reasonably practicable.

- Other guidelines produced by Oil & Gas UK Well Life Cycle Practices Forum:
  - Guidelines for well-operators on well examination
  - Guidelines for well-operators on competency of well examiners
  - Guidelines on competency for wells personnel
  - Guidelines for the suspension and abandonment of wells
  - Guidelines on the qualifications of materials for the suspension and abandonment of wells.

- The Energy Institute publication:
  - Model code of safe practice Part 15: Area classification code for installations handling flammable fluids.

- In the absence of national, CEN or ISO standards, the oil and gas exploration and production industry uses standards produced by the American Petroleum Institute (API):
  - API HF1 Hydraulic fracturing operations – Well construction and integrity guidelines
  - API HF2 Water management associated with hydraulic fracturing
  - API HF3 Practices for mitigating surface impact associated with hydraulic fracturing
  - API RP 14B Design installation, repair and operation of subsurface safety valve systems (ISO 10417)
  - API RP 53: Recommended practices for blowout prevention equipment systems for drilling wells.

SECTION 5 : ENVIRONMENTAL CONSIDERATIONS

5.1 ENVIRONMENTAL AGENCY (EA), SCOTTISH ENVIRONMENTAL PROTECTION AGENCY (SEPA) AND ENVIRONMENTAL AGENCIES OF WALES AND OF NORTHERN IRELAND

The UK Environmental Agencies have the responsibility of protecting the environment and for the exploration and extraction of unconventional gases for which they:

- provide advice to government and regulate businesses to make sure the environment is protected
- advise government on the sustainability of these sources of natural gas and their associated extraction technologies
- ensure that the exploration and development of unconventional gas is regulated effectively to manage risks to surface and groundwater resources
- are responsible for granting any necessary environmental permits (under the Environmental Permitting Regulations 2010) and have powers to serve notices where required to protect the local environment.

This is done by applying a proportionate and risk-based approach to preventing pollution and protecting the environment.

Note: Further information can be obtained from DECC, see https://www.gov.uk/government/organisations/department-of-energy-climate-change.

5.2 PERMIT APPLICATION

The EAs are a statutory consultee in the planning process and will provide advice to local authorities on individual gas extraction sites. They are responsible for:

- regulating water abstraction
- regulating any discharges associated with the extraction processes.

5.3 OTHER ORGANISATIONS

The EAs are in on-going dialogue with partner regulatory organisations and the Department of Energy and Climate Change (DECC), as well as individual unconventional gas operators and:

- **DECC** administers a licensing system under the Petroleum Act 1998, which authorises each particular drilling and development activity
- the **planning authority** (generally the local authority), deals with applications for planning permission
- **HSE** regulates the safety aspects of this work, which contributes to mitigating the environmental risk. In particular, they are responsible for regulating the appropriate design, construction and continued integrity of any gas well
- the **Coal Authority** (for coal bed methane) regulates access to the nation's coal, and will be the principal regulator of any potential future underground coal gasification sites
- **SEPA** regulates discharges to the environment as well as being a statutory consultee in the planning process in Scotland.

5.4 THE ENVIRONMENTAL IMPACTS OF UNCONVENTIONAL GAS EXTRACTION

Unconventional gas extraction involves drilling a borehole into a particular geological formation (shale or coal seam) and extracting gas which is then used to generate electricity or injected into the National gas grid. This can present several risks to the environment including:

- use of clean water
- migration of gas or dissolved minerals in formation waters through fractures in the confining layers to aquifers
- leakage from production wells into adjoining rock formations and aquifers
- fugitive emissions of gas to the atmosphere
- spills of fluids that come to the surface from storage tanks or lagoons
- induced seismicity.

All these risks can be controlled through proper design and management of the site.

5.5 THE PROCESS FOR UNCONVENTIONAL GAS EXTRACTION

The process for unconventional gas extraction includes some, though not necessarily all of the following steps:

- abstracting water from the target formation
- injecting fluid (a mixture of water, sand, and chemicals called fracking fluid) into the target formation under pressure to hydraulically fracture the rocks
- extracting return fracking fluids along with methane
- temporary venting and flaring of excess gas during the exploration phase
- use of green completion technologies to minimise venting and flaring of excess gas
- burning extracted methane on site to generate electricity
- refining gas and/or adding odorant to gas onsite to inject into the mains
- storage and treatment of wastewater onsite and discharge to a local watercourse, or transport of wastewater for treatment/disposal offsite at a suitable waste treatment facility
- underground coal gasification, unlike shale gas and coal bed methane extraction, involves the partial combustion of coal underground to produce a mixture of gases for extraction.

SECTION 6 : CONSIDERATIONS FOR SITE MONITORING

6.1 NATURAL GAS AND OTHER EMISSIONS

Venting and flaring of Natural Gas and other emissions are controlled through conditions of Petroleum Exploration and Development Licences. HSE expects controls under the Borehole Sites and Operations Regulations and Offshore Installations and Wells (Design and Construction) Regulations to be applied. Local authorities are responsible under the Environmental Protection Act to inspect sites for odour and noise associated with the venting or flaring of gas. Local authorities also have a statutory duty under the Air Quality Standards Regulations to monitor emissions to ensure they do not breach local air quality standards.

As gas transportation and distribution companies have duties under GS(M)R to provide emergency gas escape detection and repair, where appropriate well site area details should be lodged with the relevant Gas Transporter.

Methane contained in wastewater can be regulated by the appropriate environmental agency placing controls on operators' waste management plans.

The Industrial Emissions Directive would apply if gas is processed before injection into the gas pipeline or combusted to generate electricity and/or heat onsite. A permit would then be needed, requiring the operator to monitor emissions of Natural Gas (and other air pollutants). Shale gas in the UK is expected to be of high quality, so large scale processing may not be necessary. Operators will be required to monitor potential leakages of Natural Gas and other emissions before, during and after gas extraction operations. Monitoring before operations would indicate the effects of Natural Gas in the area or natural seepage (methane is released naturally from alluvium soils, landfill sites and peat deposits). One option would be to construct semi-permanent monitoring stations around the perimeter of a drilling site. Alternatively, emissions could be monitored near to the well. Both options face complications. Gas emissions would be diluted in the atmosphere before reaching monitoring stations, limiting their detection accuracy. Monitoring equipment near to the well could be disturbed due to surface equipment being changed at different stages of operations.

6.1.2 While regulatory controls and best practice can effectively manage environmental risks associated with onshore natural gas extraction, it is through appropriate independent monitoring that compliance can be demonstrated. Operators ought to adopt a formal Environmental Risk Assessment (ERA) approach, in line with best practice, to identify and manage the specific environmental risks at their sites (see Appendix 3). As part of the ERA the source-pathway-receptor model could be adopted so that risks can be reduced to As Low as Reasonably Practicable (ALARP) using Best Available Techniques (BAT). Independent, site-specific monitoring of the air, soil and groundwater before, during and after gas extraction operations occur will form an important element of the environmental risk management process.

6.1.3 Over time, monitoring equipment and techniques have improved and it is now possible in many situations for continuous monitoring techniques to be used. Monitoring procedures ought to be adopted to provide sufficiently robust data to meet the needs, as identified by the ERA, of the regulators, the local communities and interested third parties.

Specifically, the environmental risks in Table 1 may require monitoring.

Environmental Risk	Regulatory Controls	Regulators
Groundwater pollution	• Water Framework Directive • Water Resources Act • Environmental Permitting Regulations (2010) (EPR)	• Environment Agency (EAs and SEPA)
Surface spills	• Planning Regime (planning permission and attached conditions for site construction standards) • EPR	• Local Planning Authority • EAs and SEPA
Fugitive emissions	• Offshore Installation and Wells (Design & Construction) Regulations • Petroleum Exploration and Development Licence (PEDL) conditions • EPR and possibly the Mining Waste Directive	• HSE • DECC • EAs and SEPA

TABLE 1 – ENVIRONMENTAL RISK MONITORING

6.1.4 Depending on the specific objective, monitoring may be carried out at the point source of a potential or actual emission, at the boundary of the operation (fence-line monitoring) or at a receptor. Receptors may include an aquifer, surface water course, nearby residential properties or the general atmosphere in the case of green-house gas emissions.

Monitoring may be carried out at regular intervals or continuously. Continuous monitoring linked to data loggers will record actual variation in the concentration of an emission over time, while regular (spot monitoring) will only record emissions at a particular date and time. Also, continuous monitoring is often undertaken for health and safety purposes where instead of recording actual values the monitoring equipment will trigger an alarm if a pre-set level is exceeded.

6.1.5 It is important to note that petroleum hydrocarbons are naturally occurring while many of the fuels, lubricants and chemicals used in onshore natural gas extraction are common to other industrial processes. Therefore, these compounds may be present at a proposed exploration site. Baseline monitoring, carried out before operations commence, will characterise the background concentrations of these identified compounds against which any future impacts can be compared.

6.1.6 Independent monitoring ought to be carried out by specialist companies with the appropriate level of professional expertise and experience.

6.2 METHANE MONITORING TECHNIQUES

6.2.1 The measurement of methane emissions is driven by safety, environmental and economic considerations. For leak detection, it is vital to assess if the released levels are in an flammable range as well as the location and rate of leak. In this situation, methane is measured using lower flammable level (LFL) measurement systems. This is not specific to methane, but includes other gaseous hydrocarbons that can form an explosive mixture.

6.2.2 Further away from the local production equipment, it is important to know that methane is not significantly above the background level at or beyond the plant boundary. This is often tested using fenceline monitoring.

6.2.3 Monitoring and control of fugitive methane from unconventional gas operations can be achieved as follows:

- at the fenceline and in the medium field, measurements can be used for the assessment of methane flux (the mass release rate over a period of time from a particular installation). At larger scales, the overall impact of multiple wells and associated infrastructure on methane concentrations and fluxes can be assessed on a regional basis and monitoring requirements will change over time requiring different approaches:
  - prior to any drilling, background methane levels would be required
  - during drilling and production there will be an emphasis on monitoring fugitive releases, primarily driven by safety and operational maintenance to deliver leak detection and repair programmes. Fenceline measurements can be used to evaluate the performance of an individual installation, while measurements within the wider community can be used to investigate potential environmental impacts including incident response. Wider scale methane measurements can also be used to estimate methane fluxes
  - after well closure methane monitoring can be used as part of the maintenance of capped wells.

6.2.4 A wide range of measurement methods are available, these include techniques for:

- assessment of leak rates
- measurement of emissions from wellhead and associated production plant sources
- leak detection and emission rate screening
- discrete ambient measurements
- path integrated optical remote sensing for concentration and flux measurements
- tracer gas correlation
- carbon speciation.

Combining methane measurement with additional data collection can enable methane emission rates to be estimated. It is possible with the use of monitoring in conjunction with dispersion modelling to develop estimates of methane release rates from wide areas (see "Monitoring and control of fugitive methane from unconventional gas operations" by the Environmental Agency published in August 2012).

6.3 SEISMIC MONITORING

A detailed risk assessment (which forms part of the Hydraulic fracturing programme) is required as part of the DECC frac consent. This will include an assessment for any potential induced seismicity and will also describe control and mitigation measures for fracture containment.

Note: 1 Further guidance on the Hydraulic fracturing Programme can be in UK Onshore Shale Gas Well Guidelines.

Note 2: Further information can be obtained from the independent report on induced seismic mitigation published in 2012 for DECC (Preese Hall Shale Gas Fracturing, Review and Recommendations for Induced Seismic Mitigation). DECC have produced a synopsis of common questions and answers on Shale Gas and Hydraulic fracturing (fracking) which is available from their website (https://www.gov.uk/government/organisations/department-of-energy-climate-change).

SECTION 7 : CONSIDERATION OF GAS QUALITY

Consideration of the gas quality needs to be made to establish whether the gas supply is to be injected into the National Transmission System (NTS) or National gas distribution system or used directly for heat and/or power generation.

7.1 GAS FOR THE NTS OR DISTRIBUTION SYSTEM

Gas supplied into the NTS must conform to GS(M)R to be injected into the Network.

Note: IGEM/TD/16 provides guidance on injecting biomathane into the Distribution system.

7.1.1 Measurement of gas constituents

To be consistent with the GS(M)R and the network entry specification, units of measurement for all gaseous components will usually be in mole % except for all sulphur compounds which will be in mg m^{-3}.

7.1.2 Gas clean-up and removal of contaminants

Gas typically requires some processing and clean up to remove or reduce the concentration of contaminants to produce a gas that may be acceptable for use within natural gas grids. The type of gas processing required is dependent on the non conventional sources (NCS) of gas but would typically involve removal of water, carbon dioxide and hydrogen sulphide. These primary contaminants require processing as they are limited, either directly or indirectly, by GS(M)R. In addition, if non-conventional gas quality measurements indicated the significant presence of other compounds then these too would require removal. The difficulty arises in deciding which compounds are significant. Some are significant at relatively low concentrations, for instance mercury, whereas others may be acceptable with higher concentrations.

The main types of non-conventional gas clean-up techniques are:

- Water Wash
- Amine Wash
- Cryogenic
- Pressure Swing Adsorption
- Membranes.

The main aim of the processing and upgrading process is to increase the methane content of the gas and reduce other bulk components.

Note: Further information about clean up of gases and other related issues are explained in HSE RR882 research report 'Hazards arising from the conveyance and use of gas from Non-Conventional Sources (NCS)'

7.2 GAS FOR HEAT AND/OR POWER GENERATION

Gas supplied for heat and power generation needs to be monitored for continued acceptance by the requirements of the gas engine or process equipment.

SECTION 8 : ODORISATION, GAS STORAGE AND TRANSPORTATION

8.1 GENERAL

8.1.1 Dependent upon the requirements of the gas user, other considerations are:

- does the gas need to be odorised?
- does the gas need to be stored?
- what is the required gas pressure regime for transportation?

8.1.2 Odorisation

The requirements for odorisation are described in IGEM's Standard IGEM/SR/16 Odorant systems for gas transmission and distribution.

Note: Natural Gas may not be conveyed on a network below 7 bar unless odorised (see GS(M)R Regulation 8(1)).

GS(M)R states that gas in a distribution network below 7 barg must have a distinctive and characteristic odour to enable gas leaks to be detected and reported by the general public. Odour masking in distribution networks is a well documented phenomenon and there are many components in unconventional gas that will most likely mask completely or attenuate the effect of added odorant. For example, biogas from waste water has a "tarry' background smell, a "cleaning agent" type of smell caused by the terpenes plus some sweetness which comes from the combination of aldehydes and alcohols. The presence of hydrogen sulphide (H_2S) in any gas is very evident, and although this is a sulphur compound it has a distinctively different smell to gas odorant. Although H_2S produces an extremely strong unique odour, it would most likely not be identified as natural gas and would also most likely mask gas odorant. All odiferous compounds need to be removed or reacted to negate their odour before network entry (see HSE research report RR882).

8.1.3 Storing gas

If the gas has to be stored above ground the following IGEM Standards may apply:

- IGEM/SR/4 Variable volume gasholders storing lighter than air gases
- IGEM/SR/14 Fixed volume storage for lighter than air gases.

8.1.4 Gas pressure

In consideration of the gas pressure requirements for transporting the gas to the customer the following IGEM Standards may be appropriate:

- IGEM/TD/13 Pressure regulating installations for Natural Gas, Liquefied Petroleum Gas and Liquefied Petroleum Gas/Air
- IGEM/UP/6 Application of compressors to Natural Gas fuel systems.

8.2 PIPELINES AND INSTALLATION PIPEWORK FROM THE WELL

Dependent upon the gas pressure and the destination of the supply the following IGEM Standards may apply.

8.2.1 IGEM/TD/1 Steel pipelines and associated installations for high pressure gas transmission

This Standard covers the design, construction, inspection, testing, operation and maintenance of steel pipelines and certain associated installations, for the transmission of dry Natural Gas (predominantly methane), with or without

odorisation, at MOP exceeding 16 bar and not exceeding 100 bar. The scope may be extended beyond MOP of 100 bar but specific areas will require further justification and documentation which embraces a safety evaluation.

While the Standard may be appropriate for use with other gases, the characteristics of the gas and the consequential effect upon design, material, operations and maintenance of the pipeline have to be taken into account. In this context, other gases are those described by 1st family, other 2nd family and 3rd family gases as defined in BS EN 437.

This Standard covers operating temperatures between –25°C and +120°C inclusive.

This Standard applies to pipelines laid between points on land, including water crossings. For pipelines of which any part is offshore, additional or alternative guidance may be required for the offshore section. However, many of these requirements will remain valid.

The Standard equally applies to pipework design for certain associated installations, including above-ground valves, pig trap installations, manifolds, multi-junction stations, the main pipework at compressor stations, metering installations, connections and other off takes but does not apply for pressure regulating installations (when IGE/TD/13 applies).

8.2.2 **IGEM/TD/3 Steel and PE pipelines for gas distribution**

This Standard covers the design, construction, inspection, testing, operation and maintenance of steel and polyethylene (PE) pipelines for the distribution of dry Natural Gas (predominantly methane) (with or without odorisation) and Liquefied petroleum gas (LPG). It also covers modification and connection to existing pipeline systems.

For Natural Gas, the Standard covers pipelines of MOP not exceeding 10 bar for PE and not exceeding 16 bar for steel and at a temperature from 0°C to 20°C inclusive for PE and -25°C to 40°C inclusive for steel. For LPG, the Standard limits MOP to 2 bar in the LPG vapour phase.

This Standard covers the predominantly underground network of pipes that distribute gas from a pipeline used for gas transmission, central LPG storage facility or gas production plant, to a service or services supplying domestic, commercial and industrial premises.

This Standard is appropriate to 1st, 2nd and 3rd family gases as defined in BS 1179. However, the Standard predominately applies to pipelines carrying Natural Gas. Section 10 deals with the additional measures when distributing LPG vapour or LPG/air mixtures.

This Standard will be appropriate for other fuel gases, including those generated from landfill sites. However, cognisance will need to be taken of their different constituent characteristics and their consequent effect upon materials and operations.

This Standard applies to pipelines laid between points on land, including water crossings. For pipelines of which any part is offshore, additional or alternative guidance may be required for the offshore section. However, many of the requirements will be valid.

8.2.3 IGEM/TD/4 PE and steel gas services and service pipework

This Standard addresses Natural Gas services and Liquefied Petroleum Gas (LPG) service pipework. For the purposes of the Standard, the term "service" is used throughout and any requirements unique for LPG are identified by reference to LPG and not to "service pipework".

This Standard covers the design, construction, inspection, testing, operation, maintenance and alteration of steel and PE services for the provision of 2nd and 3rd family gases as defined in BS EN 437; mainly dry Natural Gas (predominantly methane) with or without odorisation and LPG.

For Natural Gas, the Standard covers services of MOP not exceeding 10 bar for PE and not exceeding 16 bar for steel and at a temperature between 0°C and 20°C inclusive for PE and -25°C to 40°C inclusive for steel. For LPG, the Standard limits MOP to 2 bar in the vapour phase.

This Standard is presented in four parts:

- Part 1 General. All gas services
- Part 2 Services of MOP ≤ 2 bar and diameter ≤ 63 mm
- Part 3 Services of 2 bar < MOP ≤ 7 bar and any pipe diameter
  Services of MOP ≤ 2 bar and pipe diameter > 63 mm
- Part 4 Services of 7 bar < MOP ≤ 16 bar.

8.2.4 IGEM/UP/2 Installation pipework on industrial and commercial premises

This Standard deals with the design, installation, operation and maintenance of pipework, including selection of materials and components.

This Standard applies to pipework designed to contain 2nd family gas, for example Natural Gas (NG), and 3rd family gas in the gaseous state, for example liquefied petroleum gas (LPG).

Note: It is likely that many of the requirements will be appropriate for 1st family gases, for example Town Gas, and other fuel gases, including those generated from landfill sites, but account will need to be taken of their different constituents and the consequent effect on materials and operations.

This Standard applies for MOP not exceeding 5 bar. For MOP exceeding 0.5 bar on industrial premises, any additional/more-stringent requirements in BS EN 15001 may have to be applied.

This Standard considers specifically pipework of steel, stainless steel (including corrugated stainless steel tubing), copper and polyethylene. In certain applications, the use of other materials may be specified, when such materials are required to be used in accordance with appropriate standards and/or the principles of this Standard for materials of similar properties.

When considering components of pipework, for example valves, this Standard covers a large selection of materials. However, the information is subject to the manufacturer's specification for the material in question.

This Standard covers installation arrangements made in accordance with IGEM/G/1.

8.2.5 **BS EN 15001 Gas installation pipework with an operating pressure greater than 0.5 bar for industrial installations and greater than 5 bar for industrial and non-industrial installations**

This European Standard specifies detailed functional requirements for the design, selection of materials, construction, inspection and testing of industrial gas installation pipework and assemblies with an operating pressure greater than 0.5 bar, and non-industrial gas installation pipework (residential and commercial) with an operating pressure greater than 5 bar in buildings, starting from the outlet of the network operator's point of delivery up to the inlet connection to the gas appliance; normally the inlet isolation valve.

This standard also covers the inlet connection to the gas appliance comprising of the pipework that does not fall within the scope of the appliance standard.

This standard applies to gas installations operating at ambient temperatures between -20°C and 40°C and operating pressures up to and including 60 bar. For operating conditions outside these limitations, reference should additionally be made to EN 13480 for metallic pipework.

SECTION 9 : INJECTION OF NATURAL GAS INTO THE NETWORK

In consideration of injecting the supply of gas into the national transmission system (NTS) or distribution system the following IGEM Standard may apply.

9.1 **IGEM/TD/16 BIOMETHANE INJECTION** *(This Standard is being prepared to be published in 2013)*

This Standard covers the requirements for design, construction, installation, inspection, testing, operation maintenance and de-commissioning of Network Entry Facilities (NEFs).

A Biogas Upgrading Plant is required to upgrade biogas to biomethane. Upgrading comprises removal of a large proportion of the carbon dioxide, hydrogen sulfide, other trace constituents and drying.

The NEF is the facility required to facilitate entry of biomethane into a gas network. Although biomethane contains largely methane and has properties broadly similar to those of natural gas, additional steps may be required before it can be admitted into the network. Typically a NEF may be required to perform:

(a) Enrichment with LPG (typically commercial propane to BS 5420). This may be required so as to ensure that the biomethane meets the Wobbe Index and calorific value requirements of the Gas Transporter, as set out in the Network Entry Agreement.

(b) Pressure control. Typically biomethane exits from a biogas upgrading plant at a pressure around 9-10 barg and pressure reduction is required for entry into below 7 barg networks. For entry into above 7 barg networks, compression may be required.

Note: Pressure regulating installations (PRIs) are covered in IGEM/TD/13.

(c) Flow management. This may be required if a specified flowrate of biomethane into the network is required, or if blending of biomethane with natural gas is required in order to satisfy (or partially satisfy) the Wobbe Index (WI) and calorific value (CV) requirements of the Gas Transporter, as set out in the Network Entry Agreement.

(d) Metering. The daily quantity of biomethane injected is required for commercial purposes, Regulatory purposes pertaining to the calculation of area calorific value, and for application of the Renewable Heat Incentive.

Note: Metering installations are covered in IGE/GM/8.

(e) Gas analysis. This is required for the determination of calorific value and demonstration of compliance with the gas quality requirements of the Gas Transporter), as set out in the Network Entry Agreement.

(f) Odorant injection, in accordance with the requirements of the Gas Transporter), as set out in the Network Entry Agreement.

Note: Odorant systems are covered in IGEM/SR/16.

(g) Telemetry. This is required for monitoring of biomethane flowrate, CV and gas quality and for closure of a Remotely Operated Valve (ROV), should the Gas Transporter need to ensure biomethane that is out of specification does not enter the network.

SECTION 10 : DECOMMISSIONING WELL SITE

Offshore Installations and Wells (Design and Construction, etc) Regulations require that abandonment of the well is controlled. A plan for the decommissioning of the well site ought to be part of the initial site environmental risk assessment and before decommission this then can be reviewed and any changes recorded.

This risk assessment is to include a seismic survey as recommended by the Royal Society and Royal Academy of Engineering report.

The mitigation measures that have been identified in that risk assessment need to be followed through to ensure the site being returned to further use in the knowledge that any residual risks from the site of the well and the well itself have been reduced to a low as reasonably practicable.

Provision needs to be made for ongoing site environmental monitoring for seismic activity and fugitive gas emissions.

Suitable guidance exists on the plugging and decommissioning of wells which applies to shale oil or gas wells, as to any other hydrocarbon well. It has been published by Oil & Gas UK:

- Guidelines for the suspension and abandonment of wells
- Guidelines on the qualification of materials for the suspension and abandonment of wells.

Coal bed methane wells must be plugged in accordance with criteria set by the Coal Authority. This can be found in Guidance on managing the risk of hazardous gases when drilling or piling near coal.

In view of the increased governmental and industry involvement in the exploration and exploitation of unconventional gas over the next few years there will be revised and new advice being issued by DECC and the Environmental Agencies, therefore the latest information has to be accessed by referencing the relevant government websites:

- https://www.gov.uk/government/organisations/department-of-energy-climate-change
- http://www.environment-agency.gov.uk/
- http://sepa.org.uk/.

APPENDIX 1 : GLOSSARY, ACRONYMS, ABBREVIATIONS, SYMBOLS AND UNITS

GLOSSARY

Gas industry definitions are given in IGEM/G/4 which is freely available by downloading a printable version from IGEM's website www.igem.org.uk.

Standard and legacy gas metering arrangements are given in IGEM/G/1 which is freely available by downloading a printable version from IGEM's website.

ACRONYMS AND ABBREVIATIONS

ACoP	Approved Code of Practice
ALARP	as low as reasonably practicable
API	American Petroleum Institute
BAT	best available techniques
CA	competent authority
CBM	coal bed methane
CDM	Construction (Design and Management) Regulations
CEN	Comité Européen de Normalisation
CIMAH	Control of Industrial Major Accidents Hazards Regulations
COMAH	Control of Major Accident Hazards Regulations
CoP	Code of Practice
CP	competent person
DECC	Department of Energy and Climate Change
EA	Environmental Agency
EEC	European Economic Community
ESP	emergency service provider
ERA	environmental risk assessment
QM	quality management
GB	Great Britain
GS(M)R	Gas Safety (Management) Regulations
GT	gas transporter
HSE	Health and Safety Executive
HSWA	Heath and Safety at Work Act
IGEM	Institution of Gas Engineers and Managers
ISO	International Standards Organisation
LCC	life cycle costing
LFL	lower flammable limit
LPG	Liquefied Petroleum Gas
MHSWA	Management of Health and Safety at Work Act
MHSWR	Management of Health and Safety Regulations
MOP	maximum operating pressure
NCS	non conventional sources
NEF	network entry facility
NG	Natural Gas
NTS	national transmission system
OHSAS	occupational health and safety management systems
OP	operating pressure
PAS	publicly available specification
PE	polyethylene
PEDL	petroleum exploration development licence
PSR	Pipelines Safety Regulations
PSSR	Pressure Systems Safety Regulations
PUWER	Provision and Use of Work Equipment Regulations
R&D	research and development
RIDDOR	Reporting of Incidents, Diseases and Dangerous Occurrences Regulations
SEPA	Scottish Environmental Protection Agency
UK	United Kingdom
UKOOG	United Kingdom Onshore Operators Group.

SYMBOLS

CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
H_2S	hydrogen sulphide
≤	less than and equal to
≥	greater than and equal to
<	less than
>	greater than.

UNITS

bar	bar
barg	bar gauge
mm	millimetre
m	metre
hectare	ten thousand square metres
mg m^{-3}	milligram per cubic metre
°C	degree Celsius.

APPENDIX 2 : REFERENCES

A2.1 **LEGISLATION**

This sub-appendix lists legislation referred to in this Guidance as well as legislation not referenced but which may be applicable.

- Water Environment (Water Framework Directive) (England and Wales) 2003
- Environment Act 1990 as amended
- Environmental Assessment Act (Scotland) 2005
- Environmental Protection Act 1990
- Gas Act 1965 as amended
- Health and Safety at Work etc. Act 1974
- Oil and Pipelines Act 1985 as amended
- Water Resources Act 1991
- Air Quality standards Regulations 2010
- Environmental Permitting Regulations 2010
- Borehole Sites and Operations Regulations 1995
- Control of Major Accident Hazard Regulations (COMAH) 1999 as amended
- Construction (Design and Management) Regulations 1994 & 2007
- Construction (Design and Management) Regulations (Northern Ireland) 2007
- Control of Industrial Major Accidents Hazards Regulations 1984 as amended
- Dangerous Substances and Explosive Atmospheres Regulations 2002
- Environmental Permitting Regulations 2010
- Gas Safety (Management) Regulations 1996
- Management of Health and Safety at Work Regulations 1992 as amended
- Management of Health and Safety at Work Regulations (Northern Ireland) 2000 as amended
- Offshore Installation and Wells (Design and Construction etc) Regulation 1996
- Pipelines Safety Regulations 1996 as amended
- Pipelines Safety Regulations (Northern Ireland) 1997
- Pressure Systems Safety Regulations 2000
- Pressure Systems Safety Regulations (Northern Ireland) 2004
- Provision and Use of Work Equipment Regulations 1992 & 1998
- Provision and Use of Work Equipment Regulations (Northern Ireland) 1993 & 1999
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (Northern Ireland) 1997 as amended
- Town and Country Planning Act 1990
- Town and Country Planning Act (Scotland) 1997
- Traffic Management Act 2004.

A2.2 **HSE**

- HSG47 Avoiding danger from underground services, Guidance
- HSG48 Reducing error and influencing behaviour
- HSG65 Successful health and safety management
- HSG150 Health and safety in construction
- HSG191 Emergency planning for major accidents, Guidance
- HSG250 Guidance on permit to work systems
- HSG253 The safe isolation of plant and equipment
- HSR25 Memorandum of guidance on the Electricity at Work Regulations
- HSL21 Management of health and safety at work, ACoP and guidance
- HSL22 Safe use of work equipment
- HSL56 Safety in the installation and use of gas systems and appliances
- HSL72 Borehole Sites and Operations Regulations, Guidance
- HSL73 A guide to reporting injuries, diseases and dangerous occurrences
- HSL80 Gas Safety (Management) Regulations. Guidance
- HSL81 Design, construction and installation of gas service pipes, ACoP and guidance for PSR
- HSL82 A guide to the Pipelines Safety Regulations
- HSL111 A guide to the Control of Major Accident Hazards Regulations
- HSL122 Safety of pressure systems
- HSL134 Design of plant, equipment and workplaces; Dangerous Substances and Explosive Atmospheres Regulations 2002. ACoP and Guidance
- HSL135 Storage of dangerous substances; Dangerous Substances and Explosive Atmospheres Regulations 2002. ACoP and Guidance
- HSL136 Control and mitigation methods; Dangerous Substances and Explosive Atmospheres Regulations 2002. ACoP and Guidance
- HSL137 Safe maintenance, repair and cleaning procedures; Dangerous Substances and Explosive Atmospheres Regulations 2002. ACoP and Guidance
- HSL138 Dangerous Substances and Explosive Atmospheres Regulations 2002. ACoP and Guidance
- HSL144 Managing health and safety in construction
- INDG178 Written schemes of examination
- INDG261 Pressure systems
- INDG370 Fire and explosion; How safe is your workplace? A short guide to the Dangerous Substances and Explosive Atmospheres Regulations 2002.
- RR882 HSE Research report "Hazards arising from the conveyance and use of gas from Non-Conventional Sources (NCS)".

A2.3 **BSI STANDARDS**

- BS 1179-6 Glossary of terms used in the gas industry
- BS EN 437 Test gases, test pressures, appliance categories
- BS EN 15001 Gas installation pipework with an operating pressure greater than 0,5 bar for industrial installations and greater than 5 bar for industrial and non-industrial installations

- BS EN 13480 Metallic industrial piping
- BS ISO 9001 Quality management systems
- BS ISO 14001 Environmental management systems.

A2.4 **IGEM STANDARDS**

- IGEM/G/1 Defining the end of the network, a meter installation and installation pipework
- IGEM/G/4 Definitions for the gas industry
- IGE/GL/8 Reporting and investigation of gas related incidents
- IGEM/SR/4 Variable volume gasholders storing lighter than air gases
- IGEM/SR/14 Fixed volume storage for lighter than air gases
- IGEM/SR/16 Odorant systems for gas transmission and distribution
- IGEM/TD/1 Steel pipelines for high pressure gas transmission
- IGEM/TD/3 Steel and PE pipelines for gas distribution
- IGEM/TD/4 PE and steel gas services and service pipework
- IGEM/TD/13 Pressure regulating installations for Natural Gas, Liquefied Petroleum Gas and Liquefied Petroleum Gas/Air
- IGEM/TD/16 Biomethane injection *(to be published 2013)*
- IGEM/TD/17 Steel and PE pipelines for biogas distribution *(to be published 2013)*
- IGEM/UP/2 Installation pipework on industrial and commercial premises
- IGEM/UP/6 Application of compressors to Natural Gas fuel systems.

A2.5 **MISCELLANEOUS**

- OHSAS18001. Occupational health and safety management systems
- PAS 55. Asset management
- Shale gas extraction in the UK; A review of hydraulic fracking by The Royal Society and Royal Academy of Engineering
- "Monitoring and control of fugitive methane from unconventional gas operations" by the Environmental Agency (published in August 2012)
- UK Onshore Shale Gas Well Guidelines by UKOOG
- Preese Hall Shale Gas Fracturing, Review and Recommendations for Induced Seismic Mitigation by C Green, P Styles, B J Baptie.

APPENDIX 3 : EXAMPLE OF A RISK BASED ENVIRONMENTAL MONITORING SCHEME

Environmental Baseline Study (EBS) to include: • **Environmental Risk Assessment (ERA)** • **Environmental Monitoring Proposal (EMP)**	• Comprehensive review of available environmental information for area of direct influence, which includes, but is not limited to: • Shallow and deep geology • Shallow and deep hydrogeology • Groundwater abstractions & quality – potable, private and commercial • Controlled waters and surface water quality • Designated environmentally sensitive sites • Soil quality • To cover area of direct influence as a minimum • Identification of all natural (biogenic and thermogenic) and anthropogenic (biogenic) sources of methane and carbon dioxide • Risk Assessment defining all Sources, Pathways and Receptors • Baseline monitoring proposals commensurate to risks identified in Environmental Risk Assessment
Key Assumptions **(Subject to Change based upon site specifics and regulatory decisions)**	• Environmental monitoring scope is on a `pad by pad' basis unless otherwise stated • All pads are assumed to be a maximum of 1 hectare in area (i.e. a 100 m by 100 m drilling pad) • Each 1 hectare pad is assumed to be able to support up to approximately three wells • For drilling pads greater than 1 hectare, the installation of monitoring wells environmental monitoring required will be scaled up appropriately • Area of direct influence should not be smaller than the horizontal sections of the lateral wells.

SITE SENSITIVITY (FROM ERA)		LOW	MEDIUM	HIGH
PHASE	**MONITORING ELEMENT**			
BASELINE	**Installation of Shallow Environmental Monitoring Wells – Typically Targeting Drift Deposits**	• Minimum number of environmental monitoring wells to target sources of CH_4 and CO_2.	• Minimum number of environmental monitoring wells to target sources of CH_4 and CO_2 and any shallow (drift) locally used aquifers.	• Minimum number of environmental monitoring wells to target sources of CH_4 and CO_2 and any shallow (drift) locally used aquifers.
	Installation of Deep Environmental Monitoring Well/s – Typically Targeting Potable Aquifers and Aquifers that may be utilised in the future following treatment	• Environmental monitoring wells may not be needed.	• Minimum number of monitoring wells to target potable and/or potentially usable aquifers.	• Monitoring wells to target potable and/or potentially usable aquifer.
	Soil Sampling and Laboratory Analysis	• Surface soil samples to suitably cover footprint of proposed pad. • Suitable samples retained from installation of monitoring wells and scheduled for detailed soils suite.	• Surface soil samples to suitably cover footprint of proposed pad. • Suitable samples retained from installation of monitoring wells and scheduled for detailed soils suite.	• Surface soil samples to suitably cover footprint of proposed pad. • Suitable samples retained from installation of monitoring wells and scheduled for detailed soils suite.
	Shallow Continuous Ground-Gas Monitoring	• 6 months monitoring*.	• 12 months monitoring to capture seasonal variations.	• 12 months monitoring to capture seasonal variations.

*Seasonal variations unlikely to be captured

SITE SENSITIVITY (FROM ERA)		LOW	MEDIUM	HIGH
PHASE	**MONITORING ELEMENT**			
BASELINE (continued)	**Shallow Ground-Gas Sampling and Analysis – Gross Composition and Isotopic**	• Minimum one round in all monitoring wells. • Detailed isotopic analysis only if ground-gases identified.	• Gross composition and isotopic analysis quarterly in all monitoring wells.	• Gross composition monthly in all monitoring wells. • Isotopic analysis quarterly.
	Shallow Continuous Water Quality Monitoring – (Electrical Conductivity, Temperature and Level	• 6 months monitoring* only if local site conditions require.	• 12 months in one monitoring well if shallow locally used aquifer is present.	• 12 months for all shallow locally used and other deeper aquifer/s.
	Shallow Groundwater Monitoring – Standard Chemical Suite	• Monthly testing of monitoring wells and surface run-off storage pool/s (minimum 3 rounds). • Extended testing suite if site specifics require.	• Every 2 months testing of monitoring wells and surface run-off storage pool/s (minimum 6 rounds) • Extended testing suite if site specifics require.	• Monthly testing of monitoring wells and surface run-off storage pool/s (minimum 12 rounds). • Extended testing suite if site specifics require.
	Shallow Groundwater Monitoring – Dissolved Gases and Isotopic	• Single round: confirmation of presence/absence of gases. • Isotopic analysis only if needed.	• Quarterly testing of monitoring wells if gases are present.	• Monthly testing of monitoring wells if gases are present.
	Deep Groundwater Monitoring, Sampling and Analysis	• Consideration needed for suitable programme of monitoring, sampling & analysis for deep monitoring well/s. Site specific and dependent upon presence of potable aquifers and/or aquifers that could potentially be used in the future following treatment.		
	Surface and Controlled Waters Sampling and Analysis	• Quarterly (if surface and controlled waters present).	• Every 2 months (minimum 6 rounds).	• Monthly testing (minimum 12 rounds).

*Seasonal variations unlikely to be captured

SITE SENSITIVITY (FROM ERA)		LOW	MEDIUM	HIGH
PHASE	**MONITORING ELEMENT**			
OPERATIONAL: **EXPLORATION (DRILLING OF VERTICAL AND HORIZONTAL BOREHOLE/S)**	**Shallow Continuous Ground-Gas Monitoring**	• On-going in one key monitoring well.	• On-going in all monitoring wells.	• On-going in all monitoring wells.
	Shallow Ground-Gas Sampling and Analysis – Gross Composition and Isotopic	• Every six months. • Isotopic analysis only if gas identified.	• Quarterly – all monitoring wells.	• Monthly – all monitoring wells. • Isotopic analysis – quarterly.
	Shallow Continuous Water Quality Monitoring	• Only if required.	• 1 Monitoring well.	• 1 or more monitoring wells.
	Shallow Groundwater Monitoring – Standard Chemical Suite	• Monthly in one key monitoring well and surface run-off storage pool/s.	• Monthly in all monitoring wells and surface run-off storage pools.	• Monthly in all monitoring wells and surface run-off storage pool/s.
	Shallow Groundwater Monitoring – Dissolved Gases and Isotopic	• Only if required. • Isotopic analysis only if gas identified.	• Quarterly – all monitoring wells.	• Monthly – all monitoring wells. • Isotopic analysis – quarterly.
	Deep Groundwater Monitoring, Sampling and Analysis	• Consideration needed for suitable programme of monitoring, sampling and analysis for deep monitoring well/s. Site specific and dependent upon presence of potable aquifers and/or aquifers that could potentially be used in the future following treatment.		
	Surface and Controlled Waters Sampling and Analysis	• Quarterly.	• Every 2 months.	• Monthly.

*Seasonal variations unlikely to be captured

SITE SENSITIVITY (FROM ERA)		LOW	MEDIUM	HIGH
PHASE	**MONITORING ELEMENT**			
OPERATIONAL: **DURING HYDRAULIC FRACTURING ACTIVITIES**	**Shallow Continuous Ground-Gas Monitoring**	• On-going in one key monitoring well.	• On-going in all monitoring wells.	• On-going in all monitoring wells.
	Shallow Ground-Gas Sampling and Analysis – Gross Composition and Isotopic	• Fortnightly (minimum 3 rounds).	• Weekly (minimum 3 rounds).	• Weekly (minimum 3 rounds).
	Shallow Continuous Water Quality Monitoring	• Consider for one key monitoring well during hydraulic.	• 1 Key monitoring well.	• 1 or more key monitoring wells as suitable.
	Shallow Groundwater Monitoring – Standard Chemical Suite	• Weekly – 1 key monitoring well.	• Weekly – all monitoring wells.	• Weekly – all monitoring wells.
	Shallow Groundwater Monitoring – Dissolved Gases and Isotopic	• Fortnightly (minimum 3 rounds) – 1 key monitoring well.	• Weekly (minimum 3 rounds) – all monitoring wells.	• Weekly (minimum 3 rounds) – all monitoring wells.
	Deep Groundwater Monitoring, Sampling and Analysis	• Consideration needed for suitable programme of monitoring, sampling and analysis for deep monitoring well/s. Site specific and dependent upon presence of potable aquifers and/or aquifers that could potentially be used in the future following treatment.		
	Surface and Controlled Waters Sampling and Analysis	• Weekly (if required).	• Weekly.	• Weekly.

*Seasonal variations unlikely to be captured

SITE SENSITIVITY (FROM ERA)		LOW	MEDIUM	HIGH
PHASE	**MONITORING ELEMENT**			
OPERATIONAL: **EXPLORATION (WELL COMPLETION, SWABBING etc)**	**Shallow Continuous Ground-Gas Monitoring**	• On-going in one key monitoring well.	• On-going in all monitoring wells.	• On-going in all monitoring wells.
	Shallow Ground-Gas Sampling and Analysis – Gross Composition and Isotopic	• Every six months. • Isotopic analysis – only if gas identified.	• Monthly – all monitoring wells. • Isotopic analysis – only if gas identified.	• Monthly – all monitoring wells. • Isotopic analysis only if gas identified.
	Shallow Continuous Water Quality Monitoring	• Only if required during Baseline. One key monitoring well.	• 1 monitoring well.	• 1 or more monitoring wells.
	Shallow Groundwater Monitoring – Standard Chemical Suite	• Monthly in one key monitoring well and surface run-off storage pool/s.	• Monthly in all monitoring wells and surface run-off storage pools.	• Monthly in all monitoring wells and surface run-off storage pool/s.
	Shallow Groundwater Monitoring – Dissolved Gases and Isotopic	• Only if required. • Isotopic analysis only if gas identified.	• Quarterly – all monitoring wells.	• Monthly – all monitoring wells. • Isotopic analysis – quarterly.
	Deep Groundwater Monitoring, Sampling and Analysis	• Consideration needed for suitable programme of monitoring, sampling and analysis for deep monitoring well/s. Site specific and dependent upon presence of potable aquifers and/or aquifers that could potentially be used in the future following treatment.		
	Surface and Controlled Waters Sampling and Analysis	• Every two months.	• Monthly.	• Monthly.

*Seasonal variations unlikely to be captured

SITE SENSITIVITY (FROM ERA)		LOW	MEDIUM	HIGH
PHASE	**MONITORING ELEMENT**			
OPERATIONAL: **COMMERCIAL PRODUCTION**	**Shallow Continuous Ground-Gas Monitoring**	• On-going in one key monitoring well.	• On-going in all monitoring wells.	• On-going in all monitoring wells.
	Shallow Ground-Gas Sampling and Analysis – Gross Composition and Isotopic	• Only if required during baseline.	• Quarterly – all monitoring wells.	• Monthly – all monitoring wells.
	Shallow Continuous Water Quality Monitoring	• Only if required during baseline.	• One Key monitoring well.	• One or more key monitoring wells as suitable.
	Shallow Groundwater Monitoring – Standard Chemical Suite	• Monthly in one key monitoring well and surface run-off storage pool/s.	• Monthly in all monitoring wells and surface run-off storage pool/s.	• Monthly in all monitoring wells and surface run-off storage pool/s.
	Shallow Groundwater Monitoring – Dissolved Gases and Isotopic	• Only if required during baseline.	• Quarterly – all monitoring wells.	• Monthly – all monitoring wells.
	Deep Groundwater Monitoring, Sampling and Analysis	• Consideration needed for suitable programme of monitoring, sampling and analysis for deep monitoring well/s. Site specific and dependent upon presence of potable aquifers and/or aquifers that could potentially be used in the future following treatment.		
	Surface and Controlled Waters Sampling and Analysis	• Quarterly (review after 12 months with view of reducing to every six months thereafter).	• Every two months (review after 12 months with view to reducing to quarterly thereafter).	• Monthly (review after 12 months with view to reducing to quarterly thereafter).

*Seasonal variations unlikely to be captured

SITE SENSITIVITY (FROM ERA)		LOW	MEDIUM	HIGH
PHASE	**MONITORING ELEMENT**			
SUSPENSION	**Shallow Continuous Ground-Gas Monitoring**	• Monthly `Spot monitoring' of monitoring wells for 12 months. • If no gas identified – quarterly thereafter. • If gas identified – continuous monitoring of one monitoring well as necessary.	• On-going in 1 key monitoring well. • Monthly `spot monitoring' of remaining monitoring wells.	• On-going in one or more key monitoring well/s. • Monthly `spot monitoring' of remaining monitoring wells.
	Shallow Ground-Gas Sampling and Analysis – Gross Composition and Isotopic	• Only if required.	• Consider quarterly if ground-gas data indicates elevated or unusual concentrations	• Quarterly in one or more key monitoring well/s.
	Shallow Continuous Water Quality Monitoring	• Only if required.	• One key monitoring well.	• One or more monitoring well/s.
	Shallow Groundwater Monitoring – Standard Chemical Suite	• Quarterly in one key monitoring well and surface run-off storage pool/s.	• Monthly in one key monitoring well and surface run-off storage pool/s.	• Monthly in one or more key monitoring well/s and surface run-off pool/s.
	Shallow Groundwater Monitoring – Dissolved Gases and Isotopic	• Only if required.	• Consider quarterly if ground-gas data indicates elevated or unusual concentrations	• Quarterly in one or more key monitoring well/s.
	Deep Groundwater Monitoring, Sampling and Analysis	• Consideration needed for suitable programme of monitoring, sampling and analysis for deep monitoring well/s. Site specific and dependent upon presence of potable aquifers and/or aquifers that could potentially be used in the future following treatment.		
	Surface and Controlled Waters Sampling and Analysis	• Quarterly.	• Quarterly.	• Monthly for 12 months, thereafter quarterly.

*Seasonal variations unlikely to be captured

SITE SENSITIVITY (FROM ERA)		LOW	MEDIUM	HIGH
PHASE	**MONITORING ELEMENT**			
ABANDONMENT: **PAD REMOVAL AND WELL SEALING**	**Soil Sampling and Laboratory Analysis** **Surface and Imported soils** **Per pad**	• Samples taken at suitable locations. • Samples scheduled for detailed soils suite.		
	Installation of shallow environmental monitoring well – one per sealed well	• Installation of shallow monitoring well directly above sealed well. • One monitoring well per sealed well. • To capture and monitor any gas leakages from sealed well.		
	Shallow Continuous Ground-Gas Monitoring **Installation of new monitoring well above sealed well – one per abandoned well**	• One month initially. • Thereafter monthly `spot monitoring' at monitoring well for months 2-12 inclusive. • Review after 12 months with view to Abandoning site. • If gas identified within 12 month period, additional monitoring to be considered as necessary.		
	Shallow Ground-Gas Sampling and Analysis – Gross Composition and Isotopic - per well	• If gas identified sample and analyse for providence (isotopic).		

*Seasonal variations unlikely to be captured

SITE SENSITIVITY (FROM ERA)		LOW	MEDIUM	HIGH
PHASE	**MONITORING ELEMENT**			
ABANDONMENT: **PAD REMOVAL AND WELL SEALING (Continued)**	**Shallow Continuous Water Quality Monitoring – per pad**	• None.	• One key monitoring well during earthworks and sealing of well. • To extend for one month following completion of cement seal.	• One or more key monitoring well/s during earthworks and sealing of well. • To extend for one month following completion of cement seal.
	Shallow Groundwater Monitoring – Standard Chemical Suite	• Weekly during earthworks and sealing of well. Quarterly thereafter. Review after 12 months.		
	Shallow Groundwater Monitoring – Dissolved Gases and Isotopic	• None unless gas identified.		
	Deep Groundwater Monitoring, Sampling and Analysis – per pad	• Consideration needed for suitable programme of monitoring, sampling and analysis for deep monitoring well/s. Site specific and dependent upon presence of potable aquifers and/or aquifers that could potentially be used in the future following treatment.		
	Surface and Controlled Waters Sampling and Analysis	• Weekly samples during earthworks and well sealing within retained monitoring well/s. • Quarterly thereafter until 12 months.		

*Seasonal variations unlikely to be captured