The Potential Economic, Social and Environmental Impact of Onshore Petroleum Development in Northern Ireland

A Final Report by Hatch
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Key Messages

The purpose of this research has been to provide an independent assessment of the potential economic, societal and environmental impacts of the development of both conventional and unconventional oil and gas resources in Northern Ireland (NI). The results of the research will be used by policy makers to inform the formulation of policy options on onshore oil and gas exploration and development and provide Ministers with the evidence needed to make fully informed decisions about any future petroleum development.

The assessment has used methods which are common for this type of assessment, including the use of publicly available information on the resource that might exist in NI and the use of development scenarios given uncertainty about the extent of the commercially extractable resource.

One of the key policy drivers in NI, as in the rest of the world, is focused on tackling climate change (and both avoiding and managing its impacts) and the transition to net zero carbon energy by 2050. The Northern Ireland Government is committed to using this transition (and the challenges presented by the Covid-19 pandemic) to secure economic growth that delivers a fairer, more resilient and successful economy.

Despite the increase in interest from the industry in NI's oil and gas resources and some limited exploration over the last 15 years, there has been no commercial development and there remain considerable gaps in information necessary to make a meaningful estimate of the technically recoverable resources. Although it is feasible that commercial quantities of oil and gas could be identified, it is nevertheless highly uncertain. This has informed the approach through the use of development scenarios, with each of these subject to varying degrees of uncertainty linked to the geology, market conditions, consenting processes and development of supply chains.

In the context of the size of the NI economy, as well as its energy sector, the scale of potential GVA and employment impacts are shown to be relatively low, even under the high development scenario. The fairly modest scale of economic impact can be attributed to the combination of the scale of development and the relatively limited scope to capture the associated expenditure and supply chain impacts within Northern Ireland. NI is unlikely to achieve the economies of scale and low costs of production which would provide a major benefit from lower energy prices. There is the scope for further downstream economic benefits, although these are unlikely to provide a major driver for additional sector growth or attraction of major inward investors into Northern Ireland. There will also be other smaller scale economic and financial costs and benefits for NI as a whole or local communities, although these are highly uncertain.

The assessment concludes that under the no development scenario there would be no additional social and environmental impacts on the baseline conditions. Allowing for the prevailing planning and regulatory regimes, as well as potential mitigation, the assessment points to:

- The low development scenario having potential effects of moderate adverse significance related to public health, and seismicity (unconventional only)
- The medium development scenario is assessed as having potential effects of at least moderate adverse significance for the following additional topics over and above the low scenario: groundwater and surface water; GHG emissions (unconventional only); loss of soils; some landscapes and geodiversity receptors (potentially greater for unconventional wells)

- The high development scenario is assessed as having potential effects of at least moderate adverse significance for the following additional topics over and above the medium scenario: some air quality receptors; handling, storage and disposal of waste; and habitat loss, disturbance and fragmentation. The significance of the effects for the groundwater abstraction and pollution and social cohesion and community well-being receptors are assessed as being of major adverse significance.

There are potential environmental impacts for which the gaps in the available evidence makes a reliable assessment of the consequences of development, and the scope for regulatory control and good practice to adequately manage them, challenging as part of the study. This applies to all of the development scenarios set out above. Drawing on the conclusion of the all island Unconventional Gas Exploration and Extraction Joint Research Programme (UGEE JRP) , the key gaps relate to: potential pollution of groundwater aquifers as a result of the long term failure or deterioration of well integrity, as well as the migration of pollutants and gas to the aquifer as a result of the fracking process; the long term leakage of gas after well closure associated with fracked wells.

Other gaps in evidence identified in this study include evidence around the long term public health impacts effects beyond post-closure, as well as cumulative or transboundary effects for either physical or mental health and wellbeing and the lack of available evidence about the impact of induced seismic events on people, including their physical health and safety, as well as less tangible impacts on mental wellbeing, anxiety and stress. Uncertainty also exists regarding impacts from the combination of emissions from onsite machinery, HGVs, drilling and fracturing which could lead to cumulative negative effects on sensitive receptors, the impact on water resource availability, water quality and aquatic habitats and ecosystems and the fragmentation of terrestrial habitat due to development.

Executive Summary

Introduction

i. The interest in onshore petroleum exploration and exploitation, especially unconventional oil and gas, has been gathering pace in a number of countries around the world over the last decade. The exploitation of these resources offers economic benefits but is also controversial due to the potential environmental and social impacts.

ii. Recent UK and NI policy decisions around climate change and commitments to a 2050 Net Zero Greenhouse Gas (GHG) emissions target has raised the issue of whether or not it is economically, environmentally or socially appropriate to continue to licence onshore petroleum exploration and development in Northern Ireland (NI). Across the UK and the Republic of Ireland moratoria or bans are in place either on unconventional only or all forms of onshore oil and gas exploration and development.

iii. Onshore petroleum exploration, on a relatively small scale, has taken place over a number of decades across NI although there has been no commercial development. The petroleum licensing regime is devolved to the Northern Ireland government and in 2019 the Department for the Economy NI undertook an initial review of it. The review highlighted that, whilst remaining functional, the licensing regime is not considered sufficiently flexible to balance increasing societal and environmental responsibilities with economic benefit and there is insufficient information on the relative benefits and disbenefits of development.

iv. The strategic issues of climate change and the setting of challenging decarbonisation targets for the UK requires NI to consider its position on continued exploration for hydrocarbons (including its 'open door' to licence applicants). In addition, there is an unprecedented level of interest from communities and interest groups, with a very strong objection to development proceeding due to concerns about the health, social and environment impacts. BEIS's public attitudes survey shows the opposition to shale gas exploitation in the UK has increased from 21% to 40% between 2013 and 2019[1].

v. The purpose of this research has been to provide an independent assessment of the potential economic, societal and environmental impacts of the development of both conventional and unconventional oil and gas resources in NI (section 1 provides a fuller description of the research objectives and questions). These impacts could potentially be both positive and negative.

vi. The results of the research will be used by policy makers to inform the formulation of evidence-based policy options on conventional and unconventional oil and gas exploration and development and provide Ministers with the information needed to make fully informed decisions about any future petroleum development (as well as informing the wider debate within the UK).

vii. The assessment has taken into account the publicly available information on the resource that might exist in NI and the factors which will determine the extent to which this is economically extractable. Given the uncertainty about the technical and economically extractable resource, the assessment has used various development scenarios to test the scale and nature of

[1] Fracking for shale gas in England (nao.org.uk)

economic, social and environmental impacts given different levels of exploration and production activity. Sections 7 and 8 provide the description of the assessment methods.

What is Onshore Petroleum Development?

viii. Oil and gas reserves can be located onshore in both conventional and unconventional rock formations known as petroleum reservoirs. The nature of these reservoirs play an important part in determining how they can be accessed and the drilling and extraction methods and associated technologies which are used.

ix. Conventional reservoirs contain concentrations of oil or gas that occur in discrete accumulations or pools in the pore spaces between the rock particles/grains. Given the concentration of these pools in particular locations, they are typically accessed using vertical well bores and the oil or gas will flow or can easily be pumped to the surface. There are three main sedimentary basins within NI which are prospective for conventional hydrocarbon reservoirs– the Rathlin Basin, Larne Basin and Lough Neagh Basin.

x. Unconventional oil and gas reservoirs are found where the permeability and porosity within the rock are very low, so that the resource cannot be extracted economically through a vertical well. Rather it requires a horizontal well followed by multistage lateral hydraulic fracturing to artificially increase the permeability and porosity and recover the oil and gas. The main unconventional gas prospect in NI is the Bundoran Shale Formation in the Lough Allen Basin (part of a larger basin that extends into the Republic of Ireland). There are also potential unconventional oil and gas reservoirs within the Carboniferous rocks in the Rathlin Basin but there is relatively little information about the extent of these formations.

xi. The timescales for the phases of a development (from planning, site preparation, drilling and testing, production and decommissioning) can run up to twenty years or more. It may vary between developments of similar and different types depending on the geology and productivity of the well.

Policy Context

xii. One of the key policy drivers in NI, as in the rest of the world, is focused on tackling climate change (and both avoiding and managing its impacts) and the transition to net zero carbon energy by 2050. This will require the continuation of good progress in the decarbonisation of the energy supply, as well as major investments to achieve decarbonisation of industry, transport and the built environment.

xiii. Oil and gas are carbon-rich fossil fuels and the unabated combustion of these fuels produces greenhouse gas (GHG) emissions. The transition to a low carbon economy implies a reduction in the use of fossil fuels in NI. A key issue is therefore whether there is a role for indigenous NI oil or gas to replace the use of imported oil or gas in the transition to net zero carbon energy.

xiv. In February 2020 the Northern Ireland Assembly debated and carried a private member's motion concerning the climate crisis. The motion stated that the Assembly recognises that NI is facing climate breakdown and a biodiversity crisis and that a climate emergency should be declared.

xv. The Department for the Economy has embarked on the development of a new energy strategy to decarbonise energy by 2050. In developing its new strategy for NI, the government has considered the optimal pathways to decarbonising energy in light of the existing energy mix, the scope to reshape use and demand reduction measures. The consultation on strategy options was launched in March 2021, with the intention of publishing the full strategy at the end of 2021. The strategy vision is to secure net zero carbon energy by 2050, whilst ensuring affordable energy for users and providing opportunities to create jobs and encourage investment.

xvi. The consultation document asks a number of questions which are directly or indirectly relevant to future onshore petroleum development. These include whether the NI Government's approach to petroleum licensing should change in line with the commitment to decarbonise energy, as well as the potential role for carbon capture use and storage (CCUS) in NI.

xvii. As in the rest of the UK, the Northern Ireland Government is committed to using this transition (and the challenges presented by the Covid-19 pandemic) to secure economic growth that delivers a fairer, more balanced and resilient economy. This is reinforced by the recent publication of the 10X Economy Strategy (An Economic Vision for a Decade of Innovation).

xviii. Northern Ireland has a separate onshore petroleum licensing regime to other parts of the UK. Under the Petroleum (Production) Act (Northern Ireland) 1964 companies seeking to undertake prospective exploration, drilling for or extracting oil or gas in NI must hold a petroleum licence granted by the Department for the Economy (DfE). The application and licensing process is underpinned by regulations which, among other things, set out the arrangements for making and determining applications, the permissible terms and conditions for granting a petroleum licence, and monitoring activity.

xix. The Strategic Planning Policy Statement 2015 (SPPS) is the statement of the Department for Infrastructure's policy on planning matters that should be addressed across Northern Ireland. It reflects the Infrastructure Minister's expectations for delivery of the planning system to enable the "*orderly and consistent development of land whilst furthering sustainable development and improving well-being.*" The SPPS includes a presumption against unconventional hydrocarbon extraction until there is sufficient and robust evidence on all environmental impacts.

xx. The NI Assembly debated a motion calling for a moratorium on onshore development activity until a bill can be brought forward that bans all exploration, drilling and extraction of hydrocarbons in NI. Many of the NI local councils have passed similar motions calling for a moratorium on onshore oil and gas development.

xxi. The strategic issues of climate change and the setting of challenging decarbonisation targets for Northern Ireland requires the Northern Ireland Government to consider its position on continued exploration for hydrocarbons. The Government's position must be informed by and consistent with the future direction of the proposed NI Energy Strategy. The DfE is currently reviewing this, with this study forming part of the evidence it will consider.

xxii. Whilst the UK Government had promoted onshore oil and gas development as a means of securing the dual benefits of energy security and economic growth, moratoria on exploration and drilling unconventional resources are currently in place across Great Britain in response to the climate crisis and concerns or uncertainty over the environmental impacts[2]. The Irish

[2] conventional development on and offshore are not covered by the moratorium

Government also announced its intention in February 2021 to end the issuing of new licences for the exploration and extraction of gas, on the same basis as the 2019 decision in relation to oil.

xxiii. Prior to the moratoria, the UK Government put in place a number of initiatives in 2013 and 2014 to encourage the exploration and development of onshore oil and gas in England and Wales (although most do not apply in NI), particularly unconventional shale gas resources. This included tax incentives and allowances for developers, access rights and improved monitoring. Developers would also be expected to demonstrate good practice encouraged by the industry, such as the adoption of the Community Engagement Charter introduced by UKOOG which provides for local community payments and revenue sharing.

Global Resource and Prospectivity in NI

xxiv. Commercial exploration and production of onshore shale oil and gas has been particularly advanced in United States and Canada[3], accounting for much of the global output of unconventional oil and gas the last decade. The growth in the US has been driven by the combination of substantial reserves, advances in horizontal drilling and hydraulic fracturing, and favourable development conditions. The circumstances in the US which are favourable to large scale production include private ownership of sub-surface rights, a large number of independent operators, extensive supply chains and a skilled workforce, and an existing pipeline and supporting infrastructure.

xxv. The UK, including Northern Ireland, may have substantial conventional and unconventional resources of oil and gas which could be accessed through onshore exploration and extraction. However, despite the increase in interest from the industry over the last 15 years, there remains considerable gaps in the engineering, geological or cost information necessary to make a meaningful estimate of overall technically recoverable reserves.

xxvi. Exploration for onshore oil and gas in Northern Ireland began in 1965 and whilst oil and gas shows have been encountered they have never been discovered in commercial quantities. The basins which offer the most prospects for commercial extraction are in the Lower Carboniferous rocks of counties Fermanagh and Tyrone and the Carboniferous to Triassic rocks beneath the NE of Northern Ireland. The former has a history of gas shows from a small number of vertical exploration wells although the prospectivity is reduced by the poor quality of the low permeability tight gas sandstone reservoir targets drilled.

xxvii. In recent years the focus in the basin has shifted towards shale gas reservoirs although the use of horizontal drilling to produce gas from the tight sandstones has been proposed. Exploration in the latter is more challenging because of a thick cover of basalts above the sedimentary basins but the 2008 Ballinlea No. 1 well in the Rathlin Basin had significant gas shows, and oil samples were brought to the surface from Carboniferous conventional reservoir rocks.

xxviii. The two current licence applications within Northern Ireland, which are currently on hold due to the review of the petroleum licensing regime, have faced considerable opposition from politicians, local communities and interest groups across NI.

[3] United Nations Conference on Trade and Development, Commodities at a glance, Special issue on shale gas. 2018.

xxix. Although it is feasible that commercial quantities of oil and gas could be identified, it is nevertheless highly uncertain due to:

- The limited data on the prospectivity of the resource in NI. The exploration which has occurred to date has provided evidence that there is oil and gas in NI but there is insufficient data to establish whether it could support commercially viable production and hence reduce this uncertainty.
- The moratoria in Great Britain (for unconventional resources only) and Republic of Ireland will limit new research and exploration particularly in the case of unconventional shale gas resources, which in turn will limit the sharing of knowledge and expertise and the development supply chains which could have helped to de-risk investments in NI and reduce development costs.
- Wider market and geopolitical factors which may keep global oil and gas prices comparatively low as economies transition to net zero carbon energy. Whilst uncertain, this may make some onshore development increasingly unviable financially.
- Proposed onshore exploration and development in Great Britain and Northern Ireland, especially involving hydraulic fracturing, has faced considerable opposition from interest groups and local communities. In practice it may be increasingly difficult to overcome this opposition and to achieve the social licence to operate.

Development Scenarios

xxx. Given the considerable uncertainty over the potential development path of onshore petroleum exploration and extraction in Northern Ireland, a range of possible development scenarios have been used to test the impacts of various development paths. The scenarios take account of the publicly available information on the type, scale and location of the resource within Northern Ireland. The development scenarios are not policy scenarios and the assessment assumes the existing policy position is applicable.

xxxi. The development scenarios used in the assessment are:

- No development scenario – this scenario assumes that no exploration or commercial exploitation takes place in NI over next three decades. The purpose of including this scenario is to enable comparison to the other three scenarios which include varying amounts of development.
- Low development scenario – two developments for conventional resources and one for unconventional (total of 10 vertical wells)[4].
- Medium development scenario – three developments for conventional resources and two for unconventional (total of vertical 18 wells).
- High development scenario - five developments for conventional resources and four for unconventional (total of 34 vertical wells).

[4] In addition, different intensities of drilling activity have been assumed which allow for the potential of more or fewer laterals per well. The low and high intensity rates for lateral drilling is defined as 2 and 4 horizontals respectively for both conventional and unconventional oil and gas.

xxxii. The overall assessment covers the period between 2021 and 2050, a period of thirty years. Where impacts associated with activity undertaken up to 2050 may occur beyond this time period, the assessment considers these subject to the available evidence and certainty about their nature, scale and duration. Also, bearing in mind that this is a high-level assessment, it has not always been possible to be specific about the quantitative impacts where they may persist.

xxxiii. The analysis has confirmed that the level of development activity under all of the development scenarios is technically feasible, although the high scenario may be more challenging to achieve in practice given the various sources of uncertainty, lead times for securing development consents and the securing of supply chains especially during the earlier drilling phases.

xxxiv. The estimated total lifecycle development costs (in 2021 prices) range from £195m-£245m under the low development scenario, £351m-£441m for the medium development scenario, £663m-£833m for the high development scenario. The expenditure range under each scenario is due to differing intensities of drilling assumptions. The costs are a best estimate and have been informed by similar previous studies, engagement with industry specialists and Hatch's in-house expertise.

Review of Economic Impact Evidence

xxxv. The shale boom in North America has resulted in a significant amount of economic impact evidence related to the development of unconventional oil and gas. The US evidence points to the significant economic impacts, mostly but not wholly beneficial, resulting from the development of onshore oil and gas. This is mainly due to the specific circumstances under which the US has developed its oil and gas industry including the strength of its supply chains.

xxxvi. In comparison, the circumstances in which the UK would develop its onshore oil and gas sector are very different[5]. The moratoria in GB and the Republic of Ireland on unconventional activity (and conventional resources in the case of the Republic) are now a major constraint on the development of the sector and the associated supply chains and skills base. Achieving the critical mass needed to attain the high levels of economic impacts reported by some of the earlier UK level impact studies is impossible in the current climate.

xxxvii. Northern Ireland lacks an indigenous oil and gas sector, although it has a sizeable geosciences sector and a range of sectors which could form part of the supply chain if future oil and gas development were to occur. Nevertheless, as outlined below, the nature of the Northern Ireland economy and its infrastructure would limit the scope to secure both upstream and downstream economic benefits from future onshore oil and gas development.

NI Economic Impact Assessment

xxxviii. The approach to assessing the potential economic impact of onshore oil and gas in NI has consisted of estimating the potential upstream expenditure which could reasonably be retained within NI under each development scenario over a 30 year period and then estimating the direct, indirect and induced economic impacts which this supports in NI. The analysis points to the following estimated impacts:

[5] it is important to note that whilst the UK has around 120 sites producing oil and gas from conventional reservoirs, little is known about the associated economic impact.

- Under the No Development Scenario there is no additional economic benefit.
- The annual GVA impact ranges from £2.2m-£3.3m under the low scenario, £4.0m-£6.0m under the medium development scenario and £7.6m-£11.3m under the high development scenario.
- The annual FTE employment impact ranges form 35-45 jobs under the low scenario, to 60-85 jobs under the medium development scenario and to 110-155 jobs under the high development scenario.

xxxix. In the context of the NI energy sector as a whole, as well as the low carbon and renewable sectors, the scale of GVA and employment impacts are shown to be relatively low, even under the high development scenario. The fairly modest scale of economic impact can be attributed to the combination of the assumed scale of development and the relatively limited scope to capture the associated expenditure within Northern Ireland.

xl. The assessment also estimates the indirect tourism impacts which arise from the expenditure of transitory workers on hospitality, food and drink, and retail in the local communities neighbouring the developments. These are not included within the core impacts presented above. The estimated tourism employment impacts are modest for all development scenarios.

xli. The study provides insights into the type of employment and skills requirements that would be required if oil and gas were to be developed in Northern Ireland. Development of oil and gas would create demand for employment and skills directly within the oil and gas sector (for example requiring engineering and geology skills) and also create demand for wider skills and employment (for example in planning and construction).

xlii. The production of large-scale oil and gas could be a benefit to downstream sectors in NI, which use this as a feedstock to their existing manufacturing and energy generation activities. However, besides the power generation sector, NI currently lacks significant downstream chemicals and major energy intensive sectors which would be a ready source of demand for the oil and gas output. The benefit of cheaper feedstocks for the manufacturing sector or gas for power generation is unlikely to provide a major driver for additional sector growth (although it could safeguard employment given the cost pressures firms in these sectors face) or attraction of major inward investors into Northern Ireland.

xliii. Energy costs in NI are typically higher than the rest of the UK and EU averages, in part due to its reliance on imports. This reduces the competitiveness of the region's industry and deters inward investment. Whilst NI would undoubtedly benefit economically from lower energy prices, it is unlikely that future gas production in NI from onshore sources will provide the type of price effect experienced in the US. The main reason for this is that the sector will not be able to achieve the economies of scale and low costs of production in Northern Ireland, even with the scale of activity envisaged under the high development scenario.

xliv. Agricultural land is a major feature of Northern Ireland's current land use and a valuable economic sector. There is also a small but growing food-based visitor economy associated with this agricultural nature and public perception of high-quality environment and associated food products. The land take under all development scenarios is modest and landowners would be compensated for any associated loss of income. However, there is the potential risk of some reputational damage for the rural economy associated with perceptions about the change of use and the potential for contamination and the knock-on this may have for the agri-food and growing food tourism sectors (all concerns expressed by local stakeholders in areas which could be affected by development).

xlv. The development of onshore oil and gas in NI would also incur other financial and economic costs by the public sector (e.g. costs associated with the licensing and consenting process, regulation, policing and other public services). The National Audit Office, in a report focused on exploitation of unconventional resources in England, notes that whilst the costs associated with activity at scale are highly uncertain, these costs would nevertheless arise and need to be accounted for.

NI Social and Environmental Assessment

xlvi. The environmental and social impact assessment of the potential for onshore petroleum exploration and development in NI has drawn on a combination of qualitative and quantitative evidence from existing Strategic Environmental Assessments (SEAs) for onshore unconventional oil and gas development in the UK and other publicly available research reports covered in the review.

xlvii. It is a high-level assessment of the significance of potential impacts. It is neither a Strategic Environmental Assessment (SEA), a project-level Environmental Impact Assessment (EIA), nor a project-specific Environmental and Social Impact Assessment (ESIA). Similarly, the assessment of health themes is not a Health Impact Assessment (HIA).

xlviii. A consistent approach has been adopted to the assessment of environmental and social impacts and the evaluation of significance. The assessment has assumed that prevailing planning policies and environmental regulations are sufficient to control activities to prevent pollution and nuisance to sensitive receptors. The mitigation measures outlined in the theme chapters could be implemented, among others, as part of the licence conditions and as good industry practice on a site-by-site basis. However, assessing the effectiveness of the implementation and regulation of past, current or future planning policies and laws covering NI is not within the scope of this assessment.

xlix. The table below provides a summary of the assessment findings. It concludes that under the no development scenario there would be no additional social and environmental impacts on the baseline conditions. As this scenario does not reflect a change in the current position for onshore development, the potential benefits and disbenefits of such a change are not considered.

l. The low development scenario is assessed as having potential effects of at least moderate adverse significance for the following topics:

- Health: Public health; amenity, recreation and physical health; social cohesion and community well-being
- Noise and seismicity: felt seismicity (unconventional only).

li. In the assessment, environmental topics, compared to a number of health-related topics noted above, are generally found to be lower significance under the low development scenario as assumptions are made of a smaller footprint or influence in the context of the regional or national resource. However, as noted below, some of these topics are subject to important aspects of uncertainty which could affect this assessment and any future site specific EIA.

lii. The medium development scenario is assessed as having potential effects of at least moderate adverse significance for the following topics:

- Health: public health; amenity, recreation and physical health; social cohesion and community well-being
- Water: groundwater and surface water extraction and pollution
- Climate change: GHG emissions (unconventional only)
- Noise and seismicity: felt seismic activity (unconventional only)
- Soils: loss of soils
- Landscapes and Geodiversity: landscape and visuals; natural tourism assets; light impacts (in this instance, the potential for moderate adverse effects is assessed to be greater where there is clustering of developments in close proximity to each other). The impacts may be greater, in some regards, for unconventional drilling.

liii. The high development scenario is assessed as having potential effects of at least moderate adverse significance for the following topics:

- Health: public health; amenity, recreation and physical health
- Air quality: point-source and fugitive emissions; air quality impacts associated with construction and site traffic; dust
- Soils: loss of soils; loss of soil quality or productivity; impact on biodiversity or agriculture
- Waste management: handling, storage and disposal of waste
- Climate change: GHG emissions (both conventional and unconventional)
- Biodiversity, Flora and Fauna: habitat loss, disturbance and fragmentation
- Noise and seismicity: felt seismic activity (unconventional only)
- Landscapes and Geodiversity: landscape and visuals; natural tourism assets; light impacts (again, in this instance, the potential for moderate adverse effects is assessed to be greater where there is clustering of developments in close proximity to each other). Again, the impacts may be greater, in some regards, for unconventional drilling

liv. The significance of the effects under the high development scenario for the groundwater abstraction and pollution, especially for unconventional development activities, and social cohesion and community well-being receptors is assessed as being of major adverse significance.

lv. There are potential environmental impacts for which the gaps in the available evidence makes a reliable assessment of the consequences of development, and the scope for regulatory control and good practice to adequately manage them, challenging. This applies to all of the development scenarios which have been assessed in this report. The UGEE JRP all island study concludes that there is significant uncertainty around the following topics in particular:

- Groundwater aquifers could be polluted as a result of the failure or deterioration of well integrity
- These aquifers could also be polluted by the migration of pollutants and gas to the aquifer as a result of the fracking process

- The long term leakage of gas after well closure.

lvi. The review and impact assessment in the context of NI has identified other gaps in the available evidence. These include gaps around the long term public health impacts beyond post-closure, as well as cumulative or transboundary effects for either physical or mental health and wellbeing and the lack of available evidence about the impact of induced seismic events on people, including their physical health and safety, as well as less tangible impacts on mental wellbeing, anxiety and stress.

lvii. Uncertainty also exists regarding impacts from the combination of emissions from onsite machinery, HGVs, drilling and fracturing which could lead to cumulative negative effects on sensitive receptors, the impact on water resource availability, water quality and aquatic habitats and ecosystems and the fragmentation of terrestrial habitat due to development.

lviii. It is also important to note and acknowledge that many potential impacts are site-specific and will vary depending on the sensitivity of local receptors and the prevailing environmental and social conditions. Within the scope of this study, it is challenging to assess these beyond high level or general terms, and the assessment does not include explicit statements about receptors and potential impacts for specific sites and their neighbouring communities which could be the focus of current or future development applications.

Social & Environmental Assessment Summary

Theme	Receptor	Development Scenario	Significance
All themes listed below	All receptors listed below	No Development	N/A
Air Quality	Point-source and fugitive emissions (conventional)	Low	Minor adverse
		Medium	
		High	Moderate adverse
	Point-source and fugitive emissions (unconventional)	Low	Minor adverse
		Medium	
		High	Moderate adverse
	Air quality impacts associated with construction and site traffic	Low	Minor adverse
		Medium	
		High	Moderate adverse
	Dust	Low	Minor adverse
		Medium	
		High	Moderate adverse
Soil	Loss of soils	Low	Negligible
		Medium	Moderate adverse
		High	
	Loss of soil quality or productivity	Low	Negligible
		Medium	Minor adverse
		High	Moderate adverse
	Impact on biodiversity or agriculture	Low	Negligible
		Medium	Minor adverse
		High	Moderate adverse
Water	Groundwater and surface water abstraction	Low	Minor adverse
		Medium	Moderate adverse
		High	Major adverse
	Groundwater and surface water pollution	Low	Minor adverse
		Medium	Moderate adverse
		High	Major adverse
Waste Management	Handling, storage and disposal of waste	Low	Minor adverse
		Medium	
		High	Moderate adverse
	Exposure to radioactive waste materials	Low	Negligible
		Medium	Minor adverse
		High	
Climate Change	GHG emissions (conventional)	Low	Minor adverse
		Medium	Moderate adverse
		High	
	GHG emissions (unconventional)	Low	Minor adverse
		Medium	Moderate adverse
		High	
Biodiversity, Flora and Fauna	Habitat loss, disturbance and fragmentation	Low	Negligible
		Medium	
		High	Moderate adverse
	Invasive species	Low	Negligible
		Medium	
		High	
Cultural and Archaeological Heritage	Loss/damage to known or unknown sites or assets	Low	Negligible to Minor adverse
		Medium	

		High	
	Impacts on setting of cultural heritage	Low	Negligible to Minor adverse
		Medium	
		High	
Noise and Seismicity	Noise	Low	Negligible
		Medium	
		High	Minor adverse
	Felt seismic activity	Low	Negligible to Moderate adverse
		Medium	
		High	
Health	Health and safety	Low	Negligible to Minor adverse
		Medium	
		High	
	Public health	Low	Negligible to Moderate adverse
		Medium	
		High	
	Amenity, recreation and physical activity	Low	Negligible to Moderate adverse
		Medium	
		High	
	Social cohesion and community wellbeing	Low	Negligible to Moderate adverse
		Medium	
		High	Minor adverse to Major adverse
Landscapes and Geodiversity	Landscape and visual effects	Low	Negligible
		Medium	Negligible to Moderate adverse
		High	
	Natural tourism assets	Low	Negligible
		Medium	Negligible to Moderate adverse
		High	
	Light impacts	Low	Negligible
		Medium	Negligible to Moderate adverse
		High	
Material Assets	Land use change to industrial use	Low	Negligible
		Medium	Negligible to Minor adverse
		High	
	Impacts on agricultural land	Low	Negligible
		Medium	Negligible to Minor adverse
		High	
	Impacts on transport infrastructure	Low	Negligible
		Medium	
		High	
	Impacts on housing, services, social and community infrastructure	Low	Negligible to Minor adverse
		Medium	
		High	

1. Introduction

Introduction

1.1 The interest in onshore petroleum exploration and exploitation, especially unconventional oil and gas, has been gathering pace in a number of countries around the world in recent years, most notably the USA and Canada. The exploitation of these resources has been associated with economic benefits in these countries and has led to the USA becoming the leading oil producer in the world. However, some of the processes used to recover unconventional oil and gas (UOG) resources are controversial due to their potential environmental impacts.

1.2 Recent UK policy decisions around climate change and UK government commitments to a 2050 Net Zero Greenhouse Gas (GHG) emissions target has raised the issue of whether or not it is economically, environmentally or socially appropriate to continue to license onshore petroleum exploration and development in NI. Across the UK and Ireland, a range of moratoria or bans currently exist either on unconventional only (England, Scotland and Wales) or all forms of oil and gas exploration and development (Ireland).

1.3 Onshore petroleum exploration, on a relatively small scale, has taken place over a number of decades across Northern Ireland (NI). Only eighteen boreholes (16 exploration wells and two shallow stratigraphic boreholes) have been drilled under petroleum licences and although several wells have recorded gas and oil shows none of the exploration has led to commercial discoveries and development. However, exploration companies continue to show interest due to the geological features that suggest NI remains prospective for oil and gas.

1.4 The petroleum licensing regime is devolved to the Northern Ireland government. The existing NI licensing regime was established in the 1960s - Petroleum (Production) Act (Northern Ireland) 1964 and associated secondary legislation that have had some limited amendments since. In 2019 the Department for the Economy NI undertook an initial review of the petroleum licensing regime. The initial review highlighted that, whilst remaining functional, the licensing regime is not considered sufficiently flexible to balance increasing societal and environmental responsibilities with economic benefit. The review highlighted that there is insufficient information on the benefits and disbenefits of continuing to license exploration and that further bespoke research was required to provide the necessary evidence on the economic, environmental and social impacts of petroleum exploration.

1.5 The strategic issues of climate change and the setting of challenging decarbonisation targets for the UK requires NI to consider its position on continued exploration for hydrocarbons (including its 'open door' to licence applicants). The Department's position will need to be informed by and be consistent with the future direction of the proposed NI Energy Strategy.

1.6 As an indication of the level of public interest in this area there has been an unprecedented level of response to consultations on two petroleum licence applications undertaken in 2019, with an almost universal objection rate. BEIS's public attitudes survey shows the opposition to shale gas has increased from 21% to 40% between 2013 and 2019[6]. The responses have raised concerns in respect of the impact on the environment and local communities.

[6] Fracking for shale gas in England (nao.org.uk)

Purpose of the Research

1.7 This current research is intended to provide an independent evidence base on which to inform the NI future policy position on petroleum licensing, as well as the preparation of the new Energy Strategy. It will also help to assess the concerns over the current licence applications and inform any recommendation to the Economy Minister and the NI Executive on award or otherwise of a petroleum licence. As such, it has assessed the potential economic, societal and environmental impacts of the development of both conventional and unconventional oil and gas resources should they be discovered in NI. These impacts could potentially be both positive and negative.

1.8 This assessment has taken into account the publicly available information on the resource that might exist in NI and the factors which will determine the extent to which this is economically extractable (including geological, technical, economic, geopolitical, policy and regulatory). Given the uncertainty about the existence or size of any technical and economically extractable resource, the assessment has used various development scenarios to test the scale and nature of economic, social and environmental impacts given different levels of exploration and production activity.

1.9 The research has also considered these impacts in the context of the current and changing energy mix in NI, allowing for the transition to renewable sources of heat and power as part of a zero carbon future and for the possibility of future oil and gas production to replace imported fuels.

1.10 The results of the research will be used by policy makers to inform the formulation of evidence-based policy options and provide Ministers with the information needed to make fully informed decisions about any future petroleum development.

1.11 The specific objectives of the study are:

- Understanding, based on a current knowledge of the potential resource that might exist in NI, of the potential economic, social and environmental benefits and disbenefits to NI of the development of onshore oil and gas, in both the exploration phase and commercial extraction stages
- Identification of the key economic, social and environmental variables that may be impacted by the development of conventional and unconventional oil and gas, and to determine suitable indicators against which the impacts can be assessed
- Compare the economic, social and environmental variables to those of a continuing reliance on the importation of oil and gas and an increased reliance on renewable energy technologies
- Identification of any potential cross-border implications of the development of conventional or unconventional oil and gas
- To provide a basis to inform the development of future policy on the development of conventional and unconventional oil and gas resources in NI.

Assessment Issues and Approaches

1.12 There are a number of issues that were considered in designing the research methods and undertaking the assessment:

- There is a growing evidence base on the economic, social and environmental impacts of shale oil and gas in particular in North America. Whilst this will be a useful evidence base for this study and has informed many of the other assessments for the UK, Welsh and Scottish Governments, aspects of this experience will be far less transferable to NI.

- Given the limited development of the onshore industry in the UK (and prevention of some forms of further development through the moratoria), there are considerable uncertainties around the scale of the unconventional hydrocarbon resource, as well as some significant aspects of uncertainty related to the potential for economic, social and environmental impacts which could arise if development were to occur. The UK specific evidence which the growth of the domestic sector would normally generate will be significantly diminished by the moratoria placed on future development in GB.
- There are nevertheless a number of major strategic economic and environmental assessments which have been undertaken by the UK and devolved governments to inform their own policy positions. Although not benefiting from UK specific monitoring data and analysis gathered from UK based exploration and production activity, these are credible sources of analysis which have been used to inform this study.
- There is nevertheless the need for realism on the potential scale of some impacts of onshore development activity. For example, claims have been made about the potential for unconventional oil and gas development in particular to support a very large number of jobs and to reduce energy prices and to provide cheap feedstocks in the UK. It is very uncertain that this could materialise for NI given the potential scale of oil and gas supply from onshore development and the nature of its economy and energy markets. Also, there are aspects of uncertainty about the potential for environmental impacts despite the commissioning of island of Ireland or NI specific technical assessments (such as the UGEE JRP all island study[7] and a study considering the potential risks of induced seismicity from hydraulic fracturing in NI[8]).
- Given this uncertainty it has been important for the research team to:
  - Triangulate the evidence by drawing on a range of sources including the published literature, the comprehensive analysis of economic, social and environmental data, and engagement with government, industry, trade bodies and interest groups (as part of the evidence gathering process), as well as the team's own experience of undertaking these types of assessment across different energy sectors.
  - Use of development scenarios which incorporate different production assumptions, including no development. This is particularly important given the uncertainty about the existence or scale of technically and economically recoverable resource (also bearing in mind that the scale of estimates of recoverable resource have been scaled back significantly in some North American locations). It should be noted that these are not scenarios which relate to particular policy options.

[7] The Unconventional Gas Exploration and Extraction (UGEE) research programme was commissioned jointly by Environmental Protection Agency (EPA), the Department of Communications, Energy and Natural Resources (DCENR) and the Northern Ireland Environment Agency (NIEA). It was awarded a contract to a consortium led by CDM Smith Ireland Limited (more information can be found here: REV_EPA-Fracking-8pp-DL-Sept15-v2(HR).pdf

[8] Potential risks of Induced Seismicity from high volume hydraulic fracturing of shales in NI, BGS, February 2021

- As outlined later in the report, these scenarios are not site location specific as this is not known and do not provide a basis for assessing the impacts on specific communities.

Economic, Social and Environmental Framework

1.13 The range of economic, social and environmental themes which have been considered through the assessment, including the associated potential impact pathways which could occur under the development scenarios, are set out in Appendix A.

1.14 The assessment methods have been tailored to the different topics and types of potential impact pathways:

- The assessment of economic impacts has quantified the economic output and employment which could be supported under each of the development scenarios, whilst the wider economic impacts (impacts such sectoral effects, a change in NI's trade balance, changes in energy security and prices) are assessed through a mix of quantitative and qualitative assessment methods. This assessment does not consider the potential indirect costs which could be incurred by the public sector through onshore oil and gas development (such as administrative or policing costs) or resource costs through the change in use or value of material or natural assets. This is considered beyond the scope of this assessment.
- The assessment of social and environmental topics has qualitatively assessed potential impacts under each of the development scenarios. The site-specific nature of many of these impact types limits the scope to quantify them in an assessment of this nature, although where suitable data is available for impacts this has been used to inform the assessment. The assessment has assessed the sensitivity, magnitude and significance of the impact across the range of topics and receptors which were consider relevant. However, this is not a strategic environmental assessment as it is not testing a specific new or proposed change in a policy, programme or initiative.
- The assessment covers a thirty-year period between 2021 and 2050 which is in line with the timescale for the transition to a zero-carbon economy (although the Northern Ireland Assembly may in due course choose to adopt a shorter timeframe). Some impacts may exceed beyond this period and where that is the case then this is factored into the assessment.

1.15 Further information on the respective assessment methods is set out in sections 7 and 8.

1.16 The remainder of the report is set out across three parts in the following manner:

- (i) Key messages and executive summary

Part A

- 2. What is onshore petroleum development?
- 3. Policy, planning & regulatory frameworks
- 4. Oil and gas resources in Northern Ireland
- 5. The development scenarios

Part B

- 6. Review of socio-economic impact evidence
- 7. Assessment of economic impacts

Part C

- 8. Social and environmental impact assessment method
- 9. Air quality
- 10. Soils
- 11. Water demand and supply
- 12. Waste management
- 13. Climate change
- 14. Biodiversity, flora and fauna
- 15. Cultural and archaeological heritage
- 16. Noise and felt seismicity
- 17. Health and wellbeing
- 18. Landscapes and geodiversity
- 19. Material assets
- 20. Assessment summary

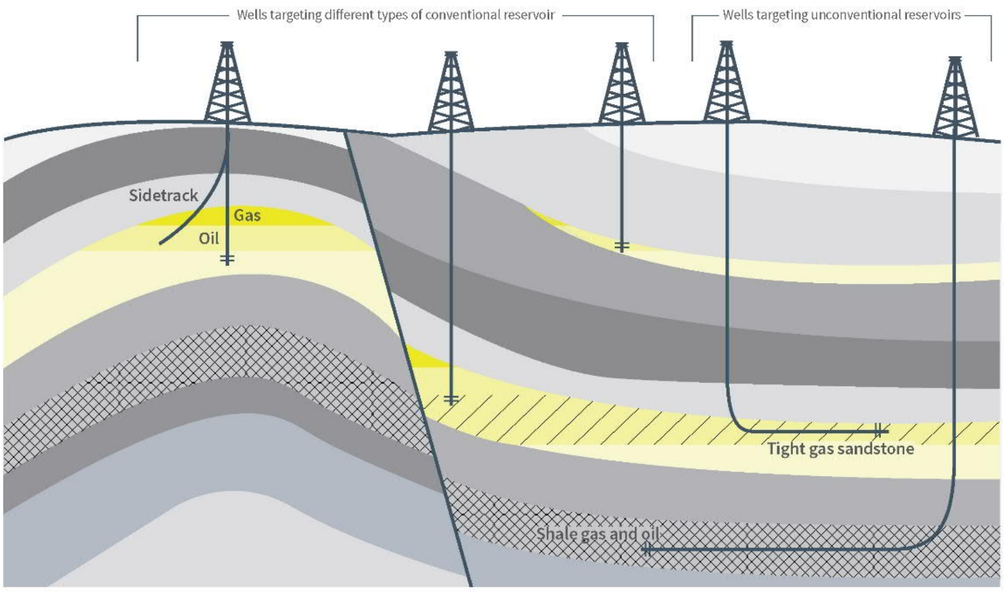
2. What is Onshore Petroleum Development?

Conventional and Unconventional Oil and Gas

2.1 Given the right geological setting and history, oil and gas resources can be located in the subsurface in onshore locations, especially where thick sediments are present in geological basins. Oil and gas may be generated from organic-rich rocks and accumulate in either conventional or unconventional reservoir rocks. The nature of these geological formations plays an important part in determining how they are accessed, including the drilling and extraction methods and associated technologies that are required.

2.2 Conventional reservoirs may contain concentrations of oil or gas that have become trapped over time in the pore space of the rock (see Figure 2.1). The rock formations hosting these hydrocarbons traditionally have high porosity and permeability and are found below impermeable rock formations. These impervious layers (seals) have provided a barrier to the upward migration of the oil and gas over geological time, resulting in the trapping of hydrocarbons in the reservoir rock. Given that the geological requirements are normally only present in a small number of locations, conventional hydrocarbons are explored for, and if found, are extracted using near-vertical well bores and with minimal reservoir stimulation. There are three main sedimentary basins within NI which are prospective for conventional hydrocarbons – the Rathlin Basin, Larne Basin and Lough Neagh Basin.

Figure 2.1 Conventional and Unconventional Oil and Gas Resources



Source: Hatch Associates

2.3 Unconventional oil and gas reservoirs are found in rock formations where both the permeability and porosity are very low, thereby not enabling the resources to be extracted economically via vertical drilling. In contrast it commonly requires a horizontal well followed by multistage laterals and high volume hydraulic fracturing to recover oil or gas. Normally the reservoir comprises a widespread low-permeability and low-porosity rock formation which is oil or gas rich, such as a shale or low permeability sandstone. Alternatively, an unconventional reservoir may also include a low-permeability and low-porosity portion of an oil or gas accumulation that cannot be developed through the standard drilling and completion processes. If the reservoir rocks consist mainly of shale, the accumulated hydrocarbons are either termed shale gas or shale oil. The main unconventional gas prospect in NI is the Bundoran Shale Formation in the Lough Allen Basin (part of a larger basin that extends into the Republic of Ireland), although the Murlough Shale Formation in the Rathlin Basin may also have unconventional gas potential.

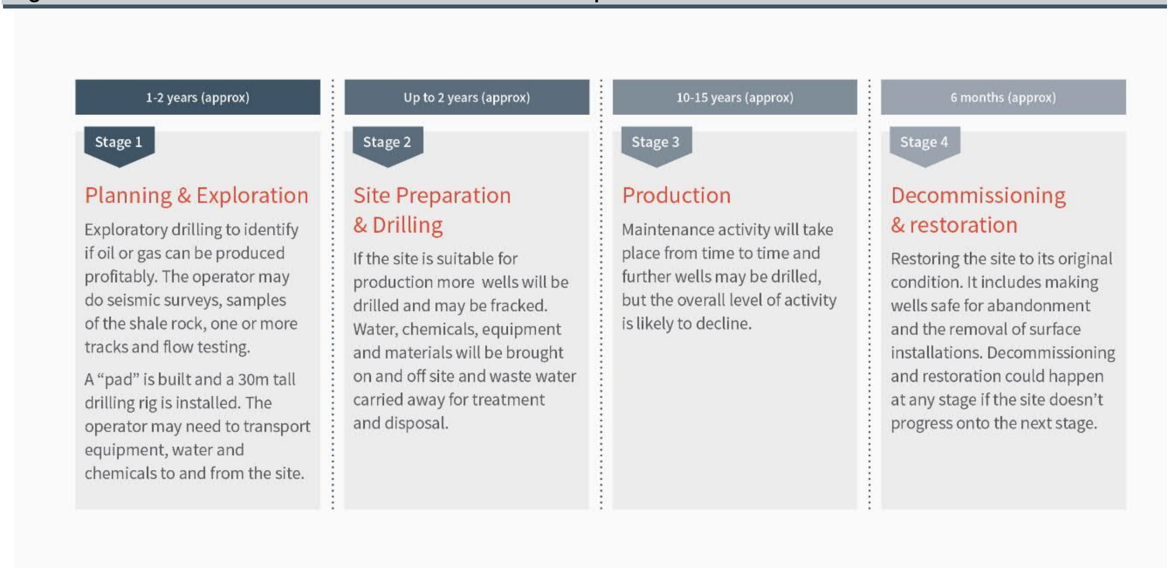
Development Stages

2.4 The indicative development cycle for a discovered resource is outlined below (see also Figure 2.2):

- Stage 1: Surveying, site selection and planning, exploratory drilling - up to 3 years
- Stage 2: Site preparation, drilling and testing – up to 2 years
- Stage 3: Production – 10-15 years
- Stage 4: Decommissioning and restoration – 6 months to a year.

2.5 The timescales for the stages are approximate and may vary between developments of similar and different types depending on the geology and productivity of the well. The production stage may be longer for conventional resources (up to 20 years), although the productivity of these wells may be significantly reduced in the later years. Shale gas wells tend to be characterised by a very steep decline from a high initial rate over the first 18 to 24 months of production. The post decommissioning stage may also involve periodic monitoring and aftercare of the well after decommissioning is complete.

Figure 2.2 Phases of Onshore Oil and Gas Development



Source: Hatch Associates, drawing on Department for Business, Energy & Industrial Strategy, Guidance on fracking: developing shale gas in the UK. 2019.

Differences in Conventional and Unconventional Development

2.6 For this assessment, scenarios for the extraction of conventional and unconventional resources are considered. The extraction of unconventional resources is a technological extension of the techniques for conventional resources. A summary of the most notable differences in the life cycle of the extraction of conventional and unconventional oil and gas is provided in Table 2.1.

Table 2.1 Differences in Stages of Extraction of Conventional and Unconventional Resources

	Conventional	Unconventional
Stage 1: Development and Exploration	Concentrations of oil or gas occur in discrete accumulations in rock formations that have high porosity and permeability and are found below impermeable rock formations. Vertical well bores with sometimes short incline or a horizontal component are used to extract the resource.	Concentrations of oil or gas in rock formations where the permeability and porosity are so low that the resource cannot be extracted economically by routine drilling and requires a horizontal well bore followed by multistage hydraulic fracturing to achieve production.
Stage 2: Drilling and site preparation	Drilling and completion of well requires up to 3MW of power running continuously while drilling.	Drilling and completion of well requires up to 3MW of power running continuously while drilling. Fracturing the well requires up to 15MW of power (largely for pumping via diesel generation) for several days per lateral. Wastewater generation from fracking activity is an order of magnitude greater due to well depth, returned fracked fluid and number of wells drilled.
Stage 3: Production and Operations	Surface plant and equipment on site for duration of operation.	Surface plant and equipment remain on site for the duration of operation, plus drilling and fracking periodically.
Stage 4: Decommiss-ioning	Conventional well sites are almost entirely restored, leaving only the wellheads, pumpjack if oil produced, and other necessary equipment, and enough space to service and maintain the well.	Unconventional well sites are almost entirely restored, leaving only the wellheads, gas/ liquid separator and other necessary equipment, and enough space to service and maintain the well.

3. Policy, Planning & Regulatory Frameworks

3.1 This section provides an overview of the policy and regulatory context for onshore petroleum exploration and production in NI, focussing upon environmental, energy, social and economic considerations. Besides policies which apply to NI, it also covers policies at the global, EU, UK and other devolved administrative areas where they are considered relevant.

Northern Ireland Policy

Draft Programme for Government 2016-21

3.2 The Draft Programme for Government provided a framework of outcomes developed by the Government after the May 2016 election. Focused on achieving outcomes of societal wellbeing and delivering real and positive change in people's lives, it represented a move from focusing on inputs and outputs to focus on the outcomes that the Executive at the time wished to achieve. These were:

We prosper through a strong, competitive, regionally balanced economy
We live and work sustainably — protecting the environment
We have a more equal society
We enjoy long, healthy, active lives
We are an innovative, creative society, where people can fulfil their potential
We have more people working in better jobs
We have a safe community where we respect the law, and each other
We care for others and we help those in need
We are a shared society that respects diversity
We are a confident, welcoming, outward-looking society*
We have high quality public services*
We have created a place where people want to live and work, to visit and invest
We connect people and opportunities through our infrastructure
We give our children and young people the best start in life

*Outcomes not included in NICS ODP

3.3 The Northern Ireland Executive has recently finished consulting on its draft outcome framework underpinning the Programme for Government 2021 (with the response not published at the time of writing). The focus of the main economy strand is to achieve an economy which is '*globally competitive, regionally balanced and carbon-neutral'.* The main theme which has increased focus in comparison to that highlighted above is the Green Economy: '*Developing our economy and energy supply in an environmentally friendly way, recognising the impacts industry has on climate change and striving for low-carbon / zero-carbon alternatives*'.

NICS Outcomes Delivery Plan

3.4 Since June 2018 and in the absence of an Executive and agreed Programme for Government, the NI Civil Service (NICS) Outcomes Delivery Plan 2018/19 (ODP) became a key strategic document, setting out the actions for departments to put in place to progress the objective of improving wellbeing for all by tackling disadvantage and driving economic growth. At the end of 2019, the

ODP actions were to be reviewed and refreshed pending the return of Ministers and production of a new Programme for Government.

3.5 The updated Plan[9] continues to be structured around the framework of 12 Outcomes of economic, environmental and social wellbeing agreed previously, and its purpose is to give renewed focus to the actions likely to achieve the biggest impact in the immediate future. Outcomes and associated indicators of relevance to the development of oil and gas in NI include:

- We prosper through a strong, competitive, regionally balanced economy
  - Energy security of supply margin
- We live and work sustainably — protecting the environment
  - Greenhouse gas emissions
  - Water quality and pollution
  - Biodiversity
- We enjoy long, healthy, active lives
  - Physical and mental health
- We have more people working in better jobs
  - Skilled workforce.

New Decade, New Approach 2020

3.6 New Decade New Approach[10] was published in January 2020, being the basis on which the NI Executive was restored. It sets out the immediate priorities for the restored Executive, as agreed by the parties:

- Transforming the health service, including the delivery of a Mental health Action Plan
- Transforming other public services
- Investing for the future, including the following sub priorities:
  - To develop a regionally-balanced economy with opportunities for all, including that NI has the right mix of skills
  - To drive the delivery of essential infrastructure projects for a prosperous shared future
  - To tackle climate change head on with a strategy to address both the immediate and longer-term impacts.
- Delivering a fair and compassionate society
- Introduce legislation and targets for reducing carbon emissions in line with the Paris Climate Change Accord

[9] https://www.executiveoffice-ni.gov.uk/sites/default/files/publications/execoffice/odp-dec-%202019.pdf

[10] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/856998/2020-01-08_a_new_decade__a_new_approach.pdf

- Developing a new Programme for Government, building on the NICS Outcomes Delivery Plan – to comprise a framework of 12 outcomes of societal wellbeing and a Priorities Plan.

Economy 2030: An Industrial Strategy for Northern Ireland[11]

3.7 The draft Industrial Strategy sets out its vision for Northern Ireland '*to be a globally competitive economy that works for everyone*' whilst noting that '*becoming the globally competitive economy to which we aspire should not mean sacrificing what makes Northern Ireland special*'. It aims to achieve this through a proposed framework of five pillars for growth. This is closely related, and in response to, the UK Government's Industrial Strategy White Paper. The pillars cover overarching themes which include inclusivity, prosperity and achieving economic rebalance :

- Pillar 1 – Accelerating Innovation and Research: by encouraging innovation through its support for continuous improvement.
- Pillar 2 – Education, Skills and Employability: by upskilling individuals and providing them with the tools to improve productivity within businesses.
- Pillar 3 – Driving Inclusive, Sustainable Growth: by providing businesses with support focused on creating sustainable improvements to business culture and attitudes towards operational excellence.
- Pillar 4 – Succeeding in Global Markets: by raising business competitiveness and contributing to export success in international markets.
- Pillar 5 – Building the Best Economic Infrastructure: by making key investments in energy, water, transport and connections, digital communications, waste disposal networks and facilities.

3.8 Northern Ireland's energy and low carbon sectors are identified as important both in terms of their role in providing the infrastructure that a modern growing economy requires (whilst also noting the trade-offs between economy, society and environment of these investments), as well as the opportunities for growth through the expansion of renewable energy sources as well as the transition to a zero-carbon economy. It notes a number of intended actions which are particularly relevant to this study including the intention of enhancing the security, sustainability and cost-efficiency of the region's energy supply, as well as developing a new Energy Strategy to meet NI's medium and longer term energy needs.

Northern Ireland Economic Recovery Plan

3.9 The Economic Recovery Action Plan sets out a range of decisive actions to kick-start economic recovery in NI in response to the challenges presented by the Covid-19 pandemic, helping to build a more competitive, inclusive and greener economy. Whilst 'Rebuilding a Stronger Economy' sets out the priorities for a more competitive, inclusive and greener economy, the Recovery Action Plan defines the immediate actions required to deliver this.

3.10 The Building a Greener Economy strand of the action plan specifically recognises that the economic recovery must be sustainable, environmentally responsible and tackle climate change. It notes in particular the opportunities presented by the shift to renewables

[11] economy-ni.gov.uk/sites/default/files/consultations/economy/industrial-strategy-ni-consultation-document.pdf

technologies, as well as the circular economy. It notes that DfE will support a Greener Economy by:

- Delivering a net zero carbon energy transition
- Improving energy efficiency of buildings and industry
- Encouraging green innovation in renewables and low carbon technologies
- Developing the Hydrogen Economy and Circular Economy
- Enabling a low carbon workforce
- Working collaboratively across Government on a green growth approach to recovery.

3.11 This is reinforced by Invest NI's (the main economic development agency in NI) recovery plan which focuses on supporting business to deal with the dual challenges of the ongoing impacts of Covid-19 and EU Exit. The Green Economy strand of the plan sets out the intention of maximising zero-carbon and Green Economy global market opportunities in areas where NI has distinct capability (e.g. Hydrogen) and support business to accelerate progress towards net zero carbon energy.

Green Growth Strategy

3.12 NI is currently developing a green growth strategy and delivery framework. Green growth is about working together to value environmental assets, growing those assets and, in so doing, growing the economy. As such, it aligns well with the draft outcome framework underpinning the Programme for Government, Rebuilding a Stronger Economy and the Northern Ireland Covid-19 Economic Recovery Plan.

3.13 The Green Growth Strategy is being co-designed by the Executive in collaboration with a broad and inclusive range of people from across the business community, environment sectors and the community and voluntary sectors. The strategy was discussed at the Executive, with co-design and consultation during autumn 2020 and a strategy due to be finalised in 2021.

3.14 The delivery framework will be a series of interconnected programmes that demonstrate green growth in action. The first will be key foundation programmes, major objectives that will contribute to the aims of the strategy but in a way that demonstrates real impact on the ground. The first announced is the Forests for our Future programme, with other key programmes expected to include keeping plastics in the economy and out of the environment, agri-environment approaches and rewarding farmers for environmental outcomes, increasing renewable energy to become a net exporter and linking up to sustainable transport to achieve net zero emissions.

Environment Strategy

3.15 Northern Ireland has not previously had an overarching environment strategy. Department of Agriculture, Environment and Rural Affairs (DAERA) is in the process of preparing a strategy which is aimed to provide an effective and holistic approach providing real improvements in the environment for the future. It has produced a public discussion document designed to give stakeholders the opportunity to express their opinions on a wide range of environmental issues facing NI.

3.16 Northern Ireland's new Environment Strategy is currently in development, taking account of the consultation responses. The strategy is expected to cover the following themes:

- Climate change
- Natural environment and landscapes
- Resource efficiency – promoting that the use of resources including oil and gas is in a way that reduces harm to the environment as much as possible.
- Marine environment
- Environmental quality (air, water and neighbourhoods)
- Fisheries and aquaculture
- Built environment.

3.17 The public consultation document also outlines six possible outcomes from the implementation of the strategy:

- We reuse and recycle our resources as much as possible and produce zero waste
- We can all access a healthy environment
- We reduce our greenhouse gas emissions and prepare for the impacts of climate change
- The loss of wildlife is stopped, our ecosystems are healthy, and our landscapes are properly looked after
- We provide and consume goods and services in ways that can be sustained in the future
- We have excellent air, water, land and neighbourhood quality.

3.18 As of early 2021, the six Strategic Environmental Outcomes for the Environment Strategy had been revised to the following:

- *Excellent air, water, land & neighbourhood quality*
- *A healthy & accessible environment everyone can connect with & enjoy*
- *Biodiversity loss in reverse, healthy ecosystems & well managed landscapes*
- *Sustainable production & consumption on and at sea*
- *Zero waste & highly developed circular economy*
- *Net zero carbon society & improved climate resilience*

3.19 The consultation document notes the particular environmental challenges which arise in NI due to the very different characteristics of our economy, our geographical location and other factors such as the prevalence of traditional fuels sources as coal and oil. This is reflected in the relative reductions in greenhouse gas emissions which have been achieved across the UK, with NI lagging behind England and Scotland.

Northern Ireland Energy Strategy

3.20 The Department for the Economy's Strategic Energy Framework (SEF)[12] was adopted in 2010 by the Northern Ireland Executive. Responding to the changed context for energy within the UK and NI, the Department for the Economy has embarked on the development of a new energy strategy to decarbonise the NI energy sector by 2050 at least cost to the consumer. In developing its new

[12] https://www.economy-ni.gov.uk/articles/strategic-energy-framework-2010

HATCH

strategy for NI, the government must consider the optimal pathways to decarbonising energy in light of the existing energy mix, the scope to reshape and demand reduction measures.

3.21 The consultation on a new energy strategy for NI was launched in March 2021, with the intention of publishing the finalised strategy at the end of 2021. The strategy vision is to secure net zero carbon energy by 2050, whilst ensuring affordable energy for users and providing opportunities to create jobs and encourage investment. It also sets out five principles at the heart of the proposed strategy:

- Placing consumers at the heart of our energy future: it aims to make energy simple for everyone in society and develop policies that enable and protect consumers through the energy transition. Affordability and fairness will be key considerations in policy decisions.
- Growing a green economy: it aims to provide economic opportunities, create new jobs and grow a low carbon skills base through innovation and focusing on NI's competitive strengths.
- Do more with less: it aims to set clear targets, standards and regulations that drive improvements in energy efficiency. Consumers will be supported to invest in changes that reduce their energy use.
- Replace fossil fuels with indigenous renewables: it aims to phase out fossil fuels by growing NI's indigenous renewable base and using this to decarbonise power, heat and transport.
- Create a flexible and integrated energy system: it aims to create a flexible, smart and digitised energy system that integrates renewables across heat, power and transport, creating value for consumers and enhancing security of supply.

3.22 The consultation document asks a number of questions which are directly or indirectly relevant to the possibility of onshore petroleum development. These include whether the NI Government's approach to petroleum licensing should change in line with the commitment to decarbonise energy, as well as whether there is a role for carbon capture use and storage (CCUS) in NI.

3.23 The option paper sets out a range of energy scenarios for achieving net zero carbon energy, namely 'business as usual', 'high electrification', 'high gasification' and 'diverse'. Of these four scenarios, the business as usual scenario is not Paris Agreement compatible, with substantially higher final energy demand than the other scenarios. The high electrification scenario has the lowest final energy demand of all scenarios due to shift to electricity (60% of total demand by 2050) and substantial improvements in energy efficiency (including that required for the increase in heat pumps) and relies mostly on electricity with 60% of final demand. The high gasification scenario has a higher level of overall final energy demand than the high electrification scenario and has the highest proportion of gas (accounting for 46% of final energy demand, compared to the high electrification (22%) and diverse scenarios (37%)). The diverse scenario takes into account the considerable regional differences in Northern Ireland and includes higher levels of local involvement as well as local responses to the low carbon transition.

Climate Emergency

3.24 In February 2020, the Northern Ireland Assembly debated and carried a private member's motion concerning the climate crisis. The motion stated that the Assembly recognises that NI is facing climate breakdown and a biodiversity crisis and that a climate emergency should be declared. Of particular relevance to this assessment, it calls on the Minister of Agriculture, Environment and Rural Affairs and the Minister for the Economy to:

- implement the commitments as agreed in the New Decade, New Approach agreement to include reviewing the Executive's strategies to reduce carbon emissions in respect of the Paris Accord
- developing a new energy strategy which will set ambitious targets and actions for a fair and just transition to net zero-carbon energy
- bringing forward a climate change act to give environmental targets a strong legal underpinning
- establishing an Independent Environmental Protection Agency to oversee this work and ensure targets are met.

3.25 In addition, the NI Assembly also debated (October 2020) a motion calling for a moratorium on onshore development activity until a bill can be brought forward that bans all exploration, drilling and extraction of hydrocarbons in NI.

3.26 Many of the NI local councils have also passed similar motions calling for a moratorium on onshore oil and gas development.

Strategic Planning Policy Statement for Northern Ireland (SPPS)

3.27 The SPPS is the statement of the Department for Infrastructure's policy on planning matters that should be addressed across Northern Ireland. It reflects the Infrastructure Minister's expectations for delivery of the planning system that enables the "*orderly and consistent development of land whilst furthering sustainable development and improving well-being.*"

3.28 The SPPS includes a presumption against unconventional hydrocarbon extraction and fracking until there is sufficient and robust evidence on all environmental impacts.

3.29 The statement supports the six guiding principles of sustainable development agreed by the Northern Ireland Executive:

- living within environmental limits
- ensuring a strong, healthy, just and equal society
- achieving a sustainable economy
- using sound science responsibly
- promoting opportunity and innovation
- promoting good governance.

3.30 A central challenge in furthering sustainable development highlighted by the SPPS is mitigating and adapting to climate change and improving air quality. It notes various ways in which this can be achieved including through shaping new and existing developments in ways that reduce greenhouse gas emissions, positively build community resilience and promoting sustainable patterns of development.

3.31 There are a number of policies and statements in the SPPS which have a bearing on potential onshore oil and gas development including archaeology and the built environment, countryside development, economic development, flood risk, natural heritage, open space and recreation, tourism transportation and waste management.

UK Policy

3.32 There is now clear recognition in UK policy that the natural environment underpins health, well-being and ultimately economic prosperity[13]. The economic benefits that flow from natural assets are increasingly taking a greater prominence in policy making, as seen in the 25 Year Environment Plan, the UK Industrial Strategy, the ambition to deliver a green EU Exit, and the UK Government's Covid-19 Recovery Strategy and drive towards a green recovery package.

25 Year Environment Plan

3.33 The 25 Year Environment Plan (25YEP) sets out the importance of enhancing natural capital in order to boost productivity as the essential basis for resilient and inclusive economic growth over the long term. Its focus areas include:

- to use and manage land sustainably
- to increase resource efficiency and reduce pollution and waste
- to connect people to the environment in order to improve health and wellbeing.

3.34 The 25YEP is also complementary to the UK's Industrial Strategy (2017), reinforcing the relationship between the environment and the economy. The Strategy's five foundations of productivity (Innovation, People, Infrastructure, Places and Business environment) are all, to a greater or lesser degree, supported by and reliant on the natural environment. The Strategy's Grand Challenges include the Clean Growth priority area as well as commitments to investment in clean innovation, lowering carbon emissions and tackling local air pollution, further showcasing the linkages between a healthy environment and thriving economy.

Net Zero Ambition

3.35 In June 2019 the UK government passed secondary legislation that committed the UK to "at least 100%" reduction in carbon emissions relative to the levels in 1990 by 2050. In April 2021 the government announced its intention to commit the UK to cutting emissions by 78% by 2035 compared to 1990 levels (as well as the UK's sixth Carbon Budget incorporating its share of international aviation and shipping emissions for the first time). However, the UK's existing Nationally Declared Contribution (NDC), a central pillar of its commitment to the Paris Agreement, does not commit the UK to net zero – this is expected to be changed in the run up to the next COP26 climate talks.

3.36 The Climate Change Committee's 2020 Progress Report suggests that the Covid-19 recovery represents an opportunity to further steer choices towards new vital economic activity that accelerates the Net Zero transition and strengthens the UK's climate change resilience. The CCC report's headline conclusion is that there is a sizeable "policy deficit" between recent, current and planned short-term action, and what is required to put the UK on track to meet its long-term climate targets. The delay to the publication of the National Infrastructure Strategy, Energy White Paper and the Buildings and Heat Strategy were highlighted as concerns, as was the lack of a clear carbon pricing trajectory.

3.37 The delay to COP26 is seen as creating a window of opportunity to establish a credible and leading position on climate change. UK Government recently revealed that a national net-zero strategy will be published before the COP26 climate summit in November 2021. To achieve Net

[13] UK Government's 25 Year Environment Plan (25YEP)

Zero, the UK needs to achieve an average emissions reduction of around 15.5 $MtCO_2e$ per year over the next 30 years, similar to the 16 $MtCO_2e$ achieved in 2019.

Energy White Paper 2020

3.38 Energy is a devolved matter within NI, however, the Energy White Paper[14] is included here as it provides further clarity on the UK Prime Minister's strategy for the wider energy system necessary to deliver net zero emissions by 2050. The White Paper notes that '*we will …make sure the natural gas markets and networks evolve in a way which enables continued investment and ensure secure supplies but also promotes the use of low-carbon options, wherever possible*'. Whilst the White Paper's focus on the oil and gas sector is mainly concerned with offshore activity, a number of the commitments could be relevant to the onshore sector including:

- Ensuring that licensing is compatible with the UK's climate change ambitions in the coming decades (including through formalising this into existing processes)
- Ensuring the UK maintains a secure and resilient supply of fossil fuels during the transition to net zero emissions.

National Infrastructure Strategy

3.39 The National Infrastructure Strategy was published in November 2020 with the intention of creating a "fairer, faster, greener" economy, as well as driving its plans to "level up" the country. The third chapter concentrates on how the infrastructure investment aligns with decarbonising energy and reducing climate change. Decarbonising the power supply, industrial decarbonisation and the shift to low emissions vehicles are seen as key priorities along the route to achieving net-zero emissions.

Republic of Ireland

3.40 In March 2021 the Irish Government approved its Climate Action and Low Carbon Development (Amendment) Bill, setting out its path to net-Zero emissions no later than 2050, and to a 51% reduction in emissions by 2030. The Bill provides an ambitious framework for Ireland to meet its international and EU climate commitments, including:

- Provision for the first of two five-year carbon budgets proposed by the Climate Change Advisory Council to equate to a total reduction of 51% over the period to 2030 (relative to a baseline of 2018)
- The inclusion of all forms of greenhouse gas emissions including biogenic methane in the carbon budgets
- The role of Government in setting out how the carbon budget will apply by sector, detailed in the annual Climate Action Plan
- Local Authorities preparing their own five-year Climate Action Plans which will include both mitigation and adaptation measures (and with alignment to Development Plans).

[14] Energy White Paper (publishing.service.gov.uk)

International Policy Perspectives

3.41 There are a wide range of international policies which also have a direct or indirect bearing on onshore petroleum development in NI. This also includes a number of European Union policies due to their legacy implications. These are outlined briefly below.

UN Sustainable Development Goals

3.42 The 2030 Agenda for Sustainable Development, adopted by all UN Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, both now and into the future. The seventeen Sustainable Development Goals (SDGs) are an urgent call for action by all countries - developed and developing - in a global partnership. They represent an integrated approach to ending poverty and other deprivations hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth while tackling climate change and working to preserve land and seascapes.

3.43 The SDGs relevant to the development of onshore oil and gas in NI include:

- Goal 3: Good health and wellbeing – ensure healthy lives and promote wellbeing for all at all ages.
- Goal 6: Clean water and sanitation – including to ensure availability and sustainable management of water.
- Goal 7: Affordable and clean energy – ensuring access to affordable, reliable, sustainable and modern energy for all.
- Goal 8: Decent work and economic growth – sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
- Goal 11: Sustainable cities and communities – make human settlements inclusive, safe, resilient and sustainable.
- Goal 13: Climate action – take urgent action to combat climate change and its impacts.
- Goal 15: Life on land – including to protect, restore and promote sustainable use of terrestrial ecosystems, reverse land degradation, and halt biodiversity loss.
- Goal 16: Peace, justice and strong institutions – including promoting peaceful and inclusive societies, and building effective, accountable and inclusive institutions for all.

UNCC Paris Agreement

3.44 The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris on 12 December 2015. Its goal is to limit global warming to well below 2 degrees Celsius. To achieve this long-term temperature goal, countries aim to reach global peaking of greenhouse gas emissions as soon as possible to achieve a climate neutral world by mid-century. The Paris Agreement is a landmark in the multilateral climate change process because, for the first time, a binding agreement brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects.

EU Environmental Policy

3.45 Whilst the UK exited the European Union at the end of January 2020, many of its policies are still relevant to NI as the policies remain embedded in or have been transferred into UK policy.

3.46 The European environment policy rests on the principles of precaution, prevention and rectifying pollution at source, and on the 'polluter pays' principle. The policy areas are:

- Combating climate change
- Biodiversity, land use and forestry
- Water protection and management
- Air and noise pollution
- Resource efficiency and the circular economy
- Sustainable consumption and production
- Chemicals and pesticides.

European Green Deal

3.47 The Green Deal is an action plan to make the EU's economy sustainable by turning climate and environmental challenges into opportunities, and making the transition just and inclusive for all. The EU aims to be carbon neutral by 2050 and proposed a European Climate Law to make the political commitment a legal obligation.

3.48 The most relevant policy areas include:

- Biodiversity
- Eliminating pollution
- Sustainable agriculture
- Clean energy
- Climate action
- Sustainable industry.

3.49 The EU is also providing financial support and technical assistance through the Just Transition Mechanism to help those member states and their communities that are most affected by the move towards the green economy. It will help mobilise €100 billion over 2021-2027 in the most affected regions.

3.50 Related EU environmental strategies include:

- EU strategies for energy system integration and hydrogen – to pave the way towards a fully decarbonised, more efficient and interconnected energy sector.
- EU strategy on Offshore Renewable Energy – while reinforcing the role of offshore energy in the energy mix, the strategy underlines that sustainability and, more specifically, the protection of the environment and biodiversity will be key principles for all dimensions concerned.
- 2030 Climate Target Plan – proposal to cut greenhouse gas emissions by at least 55% by 2030.

- EU 2030 Biodiversity Strategy – putting Europe's biodiversity on a path to recovery by 2030, with commitments including an increase in ambition on protected areas (30% by 2030, with 10% strictly protected), a binding ecosystem restoration initiative, and biodiversity funding of at least €20 billion per year based on Member State's prioritized investment needs. However, only a slight reference is made to the EU's agricultural policy representing over a quarter of the EU budget.
- State of Nature in the EU 2020 report[15] – identifies persisting pressures on Europe's nature and gives an overview of Europe's most vulnerable species and habitats protected under EU nature laws. The report identifies the top pressures affecting habitats and species as:
  - Unsustainable agriculture and forestry, urban sprawl and pollution
  - Peatlands, grasslands, dune habitats, and species associated with agriculture.

Onshore Petroleum Licensing in NI

3.51 NI has a separate onshore petroleum licensing regime to other parts of the UK and as such the UK Oil & Gas Authority (OGA) does not play any role in relation to onshore licensing and permitting in the region. Under the Petroleum (Production) Act (Northern Ireland) 1964 companies seeking to undertake prospective exploration, drilling for or extracting oil or gas in NI must hold a petroleum licence granted by the Department for the Economy (DfE).

3.52 All of Northern Ireland's onshore areas are available for petroleum licence applications. DfE is responsible for granting Petroleum Licences for all areas of Northern Ireland including the internal waters adjacent to Northern Ireland (although these internal waters have not been made available for Licence applications).

3.53 The application and licensing process is underpinned by a range of Petroleum Regulations which, among other things, set out the arrangements for making and determining applications, permissible terms and conditions for granting a Petroleum Licence and the Model Clauses which may be incorporated in a Petroleum Licence. They also specify the current criteria for determining applications for Petroleum Licences. The Licence application process involves scrutiny of the Applicant's financial viability and capacity, technical capacity and environmental awareness.

3.54 A Petroleum Licence does not grant the Licensee carte blanche to carry out all petroleum related activities. A number of activities, such as drilling, fracturing, extended well testing or suspension and abandonment of a well, are subject to individual consents from the DfE, and a Licensee remains subject to all controls by other bodies such as the Health and Safety Executive Northern Ireland (HSENI), the Northern Ireland Environment Agency (NIEA) and planning permission must be sought where required.

3.55 The granting of a Petroleum Licence in no way waives the requirement for the Licensee to get necessary permission from the landowners to carry out exploration activities on that land. It is the Licensee's responsibility to be aware of, and comply with, all regulatory controls and legal requirements, but they must demonstrate this prior to any permission to drill being given by DfE.

3.56 Petroleum Licences cover exploration, appraisal, development and production of oil and gas. In Northern Ireland, a Petroleum Licence has the following periods:

[15] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2020:635:FIN

Term	Length (years)	Phase	Work Permitted/Carried Out
Initial	5	Exploration	Evaluation of acreage, identification of prospects, exploration drilling (subject to permission).
Second	5	Appraisal & development	Further exploration or appraisal of discovery leading to submission of field development plan.
Third	20+	Production	Development of field and production period, field decommissioning.

3.57 An applicant may either apply for a Petroleum Licence with a firm commitment to drill or with a Drill-or-Drop commitment. The Initial Term of a licence comprises two parts, with Part 1 (years 1-3) of the Work Programme including early exploration activity such as geochemical sampling, seismic data acquisition, and identification of drilling targets. With a drill-or-drop commitment, licensees make a decision whether to procced to Part 2 (years 4 & 5) of the first term and drill an exploratory well subject to all permits and consents. Following the results of the drilling and if work programme is completed to the satisfaction of DfE, a licensee can proceed to the Second Term. Up to 50% of the licence area may be retained into the Second Term or the licence may also be relinquished at this point.

3.58 The Second Term, subject to obtaining any necessary permits and consents may include drilling of an appraisal well, testing programmes, analysis of drilling results, seismic and geochemical surveys and planning for the extraction of any commercially viable discoveries (the licensee will prepare and submit a Field Development Plan).

3.59 The Third Term is intended for construction of facilities and production. Subject to obtaining any necessary permits and consents activities carried out in this term may include drilling of production wells, connection to existing infrastructure, extraction of hydrocarbons and decommissioning of oil/gas fields and facilities.

3.60 As noted earlier, the SPPS assumes a presumption against unconventional hydrocarbon extraction until there is sufficient and robust evidence on all environmental impacts.

Onshore Petroleum Policies Elsewhere in the UK and RoI

3.61 Across the UK and Ireland a range of moratoria or bans exist either for unconventional only or all forms of oil and gas exploration and development:

- England – following the publication of an Oil and Gas Authority report[16] published in November 2019, the UK government announced a moratorium on hydraulic fracking until new evidence is provided on the links to seismic activity. It concluded '*that it is not possible with current technology to accurately predict the probability of tremors associated with fracking*'. The moratorium is still in place, although it does not affect drilling which does not include hydraulic fracking.
- Scotland – in 2015 the Scottish Government placed a moratorium on unconventional oil and gas development in Scotland whilst it undertook an extensive review of the evidence into the impacts of exploration and extraction. In 2019 it finalised its policy position of '*no support for UOG development in Scotland*' which covers development connected to

16 https://www.ogauthority.co.uk/exploration-production/onshore/onshore-reports-and-data/preston-new-road-pnr-1z-hydraulic-fracturing-operations-data/

the onshore exploration, appraisal or production of shale oil and gas using unconventional extraction techniques, including hydraulic fracturing.

- Wales – at the end of 2018 the Welsh Government announced its policy '*to not undertake any new petroleum licensing in Wales, or support applications for hydraulic fracturing petroleum licence consents*'.
- Republic of Ireland – the Irish Government announced its intention in February 2021 to end the issuing of new licences for the exploration and extraction of gas, on the same basis as the 2019 decision in relation to oil exploration and extraction. It will no longer accept new applications for exploration licences for natural gas or oil (conventional or unconventional) or letting any future licensing rounds. This applies to both on and offshore development. This does not affect existing approvals which are in place.

3.62 Prior to the introduction of the moratorium in England, the UK Government had indicated its support for the industry (excluding NI) by making a series of proposals to encourage safe and sustainable development including reduction in tax burdens on developers, a fund to cover provision of independent evidence on the robustness of current regulatory regime and the retention of business rates by local authorities.

3.63 A public consultation was held in 2014 on proposals to simplify underground access and exploitation of oil, gas and geothermal resources in England, Scotland and Wales (not including NI). Whilst the vast majority of respondents were opposed to underground drilling access, the Infrastructure Bill (Infrastructure Act 2015) gave underground access rights to companies extracting petroleum resources and geothermal energy in England and Wales (where it is at least 300 metres below the surface).

3.64 The Act also introduced a series of shale gas fracking safeguards setting out the conditions for the granting of a well consent for hydraulic fracturing in England and Wales:

- Requiring a separate hydraulic fracturing consent for associated hydraulic fracturing at a depth of 1000 metres and below, as well as prohibiting associated hydraulic fracturing at a depth of less than 1000 metres
- Safeguards to be in place in relation to environmental impacts (in particular, relating to groundwater), monitoring, consultation and providing public information.

3.65 DECC (now BEIS) published a Regulation and Best Practice guide[17] for onshore oil and gas development in 2015 with the intention of providing greater clarity and good practice for the permitting and permissions process, particularly with respect to unconventional resources and the use of hydraulic fracturing. A separate document covers NI.

3.66 The UK Onshore Operators Group, which is the representative body for the onshore oil and gas industry in the UK, published a Community Engagement Charter in 2013[18] setting out the commitments made by its members. Licence applicants and holders would be expected to reflect this Charter in considering their approach to good practice including community consultation and community benefits package.

[17] Onshore_UK_oil_and_gas_exploration_England_Dec15.pdf (publishing.service.gov.uk)

[18] Benefits of Onshore Oil and Gas | UKOOG

Summary

3.67 One of the key policy drivers in NI, as in the rest of the world, is focused on tackling climate change (and both avoiding and managing its impacts) and the transition to a net zero carbon economy by 2050. This will require the continuation of good progress in the decarbonisation of the energy supply, as well as major investments to achieve decarbonisation of industry, transport and the built environment.

3.68 The Department for the Economy has embarked on the development of a new energy strategy to decarbonise energy by 2050. In developing its new strategy for NI, the government has considered the optimal pathways to decarbonising energy in light of the existing energy mix, the scope to reshape use and demand reduction measures. The consultation on strategy options was launched in March 2021, with the intention of publishing the full strategy at the end of 2021. The strategy vision is to secure net zero carbon energy by 2050, whilst ensuring affordable energy for users and providing opportunities to create jobs and encourage investment.

3.69 The consultation document asks a number of questions which are directly or indirectly relevant to future onshore petroleum development. These include whether the NI Government's approach to petroleum licensing should change in line with the commitment to decarbonise energy, as well as the potential role for CCUS in NI.

3.70 As in the rest of the UK, the Northern Ireland Government is committed to using this transition (and the challenges presented by the Covid-19 pandemic) to secure economic growth that delivers a fairer, more balanced and resilient economy.

3.71 Northern Ireland is due to publish its new energy and environmental strategies in 2021. These strategies will play an important role in determining the pace and pathways which NI adopts to the transition to net zero-carbon energy and tackling the related challenges of climate change. This direction of travel is also underpinned by the draft Programme for Government and other key policies.

3.72 NI has a separate onshore petroleum licensing regime to other parts of the UK and as such the UK Oil & Gas Authority (OGA) does not play any role in relation to onshore licensing and permitting in the region. Under the Petroleum (Production) Act (Northern Ireland) 1964 companies seeking to undertake prospective exploration, drilling for or extracting oil or gas in NI must hold a petroleum licence granted by the Department for the Economy (DfE).

3.73 The strategic issues of climate change and the setting of challenging decarbonisation targets for Northern Ireland requires the Northern Ireland Executive to consider its position on continued exploration for hydrocarbons. This position must be informed by and consistent with the future direction of the proposed NI Energy Strategy. The Department is currently reviewing this, with this study forming part of the evidence it will consider.

3.74 Whilst the UK Government had promoted onshore oil and gas development as a means of securing the dual benefits of energy security (in response to declining output from the North Sea) and economic growth, moratoria on exploration and drilling unconventional resources are currently in place across Great Britain. The Irish Government also announced its intention in February 2021 to end the issuing of new licences for the exploration and extraction of gas, on the same basis as the 2019 decision in relation to oil.

3.75 Prior to the moratoria, the UK Government put in place a number of initiatives in 2013 and 2014 to encourage onshore oil and gas development in England and Wales (although most do not apply in NI). This included tax incentives and allowances for developers, access rights and improved monitoring. Developers would also be expected to demonstrate good practice encouraged by the industry, such as the adoption of the Community Engagement Charter introduced by UKOOG which provides for local community payments and revenue sharing.

4. Global Resource and Prospectivity in NI

4.1 This section sets out:

- An overview of existing research on available onshore oil and gas resources, providing global resource context for resource and reserve estimates in UK. Much of the focus is on shale oil and gas resources given the considerable interest over the past decade and improved knowledge of its extent through research and exploration (mainly in the US).
- A review of evidence on the potential for conventional and unconventional resources in Northern Ireland.
- Consideration of the factors which could influence the extent of extraction within Northern Ireland over next twenty years. This includes policy, market, geological and technical considerations factors.

Global Perspective

4.2 There has been a massive expansion in the exploration and production of onshore oil and gas, especially in North America, given the opportunities this presents to reduce the costs of energy, to enhance the energy mix and provide security of supply. This has been driven by the development of new techniques for extracting shale oil and gas, as well as a better understanding of the resource through more extensive studies and exploration activity.

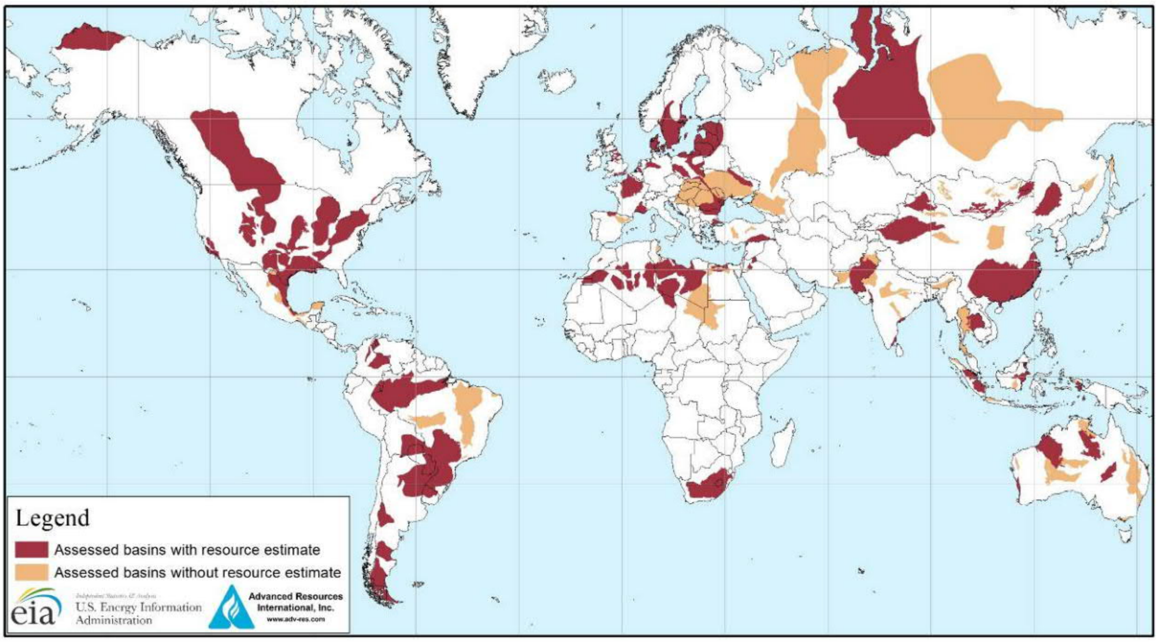
4.3 Shale gas resources are considered to be widely distributed worldwide. Based on an assessment[19] of shale formations around the world, the US EIA estimated (2013-2015 estimates, last updated 2015) the technically recoverable reserves (TRR) of shale oil and gas resources for the world to be:

- 420 billion barrels (bbl) of world shale oil resources, distributed in more than 170 shale strata in 104 basins of 46 countries (up from 350 billion barrels in 2013).
- 7,600 trillion cubic feet (tcf) of world shale gas (up from 7,300 tcf in 2013), which represents approximately 61 years of world natural gas consumption (with 2016 as reference year for demand).

4.4 The map in Figure 4.2 shows the 2013 assessment of the global extraction of shale oil and shale gas formations.

[19] https://www.eia.gov/analysis/studies/worldshalegas/

Figure 4.2 Map of basins with assessed shale oil and shale gas formations, as of May 2013



Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies.

4.5 Commercial exploration and production has been particularly advanced in the US and Canada[20], accounting for much of the global output to date. The shale gas production increased from 18.6 tcf in 2017 to 22.1 tcf in 2018 (global output of natural gas was 3,900 tcf in 2018). The EIA estimated that in 2019 US dry shale gas production was about 25.3 trillion cubic feet (tcf), equal to about 75% of total US dry natural gas production in 2019[21].

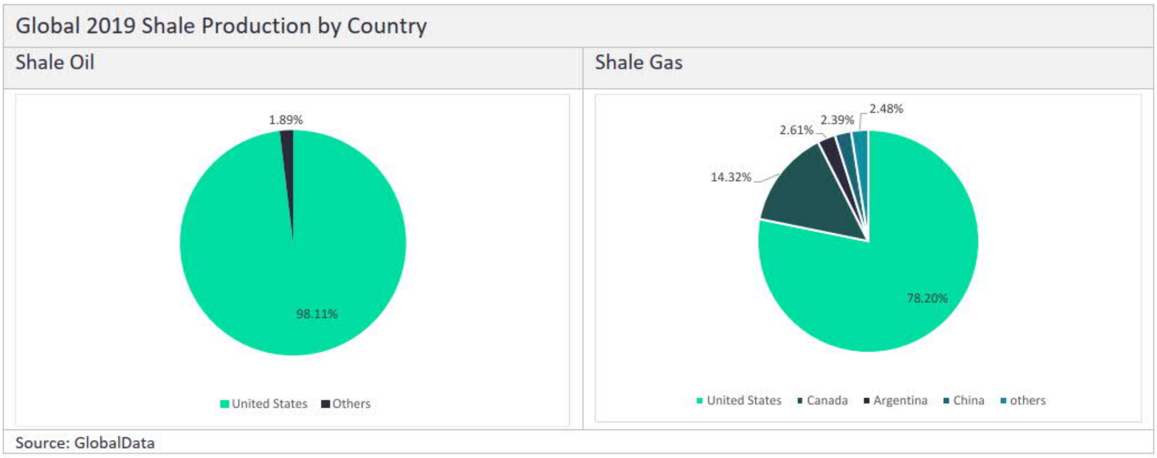
4.6 The growth in the US has been driven by the combination of substantial reserves, advances in horizontal drilling and hydraulic fracturing, falling production costs, and favourable development conditions for the oil and gas industry. There are also a set of circumstances which are also favourable to large scale production including private ownership of sub-surface rights, presence of large numbers of independent operators, extensive supply chains and a skilled workforce (in part linked to conventional onshore activity) and existing pipeline and supporting infrastructure and resources.

4.7 The U.S. is now the major producer of shale oil worldwide, producing 98% of global shale oil. The U.S. EIA estimated that in 2019, about 2.83 billion barrels of crude oil were produced directly from tight oil resources in the United States. This was equal to about 63% of total U.S. crude oil production in 2019. Figure 4.2 shows the dominance of the U.S. in production of shale oil and gas.

[20] United Nations Conference on Trade and Development, Commodities at a glance, Special issue on shale gas. 2018.

[21] https://www.eia.gov/tools/faqs/faq.php?id=907&t=8#:~:text=How%20much%20shale%20gas%20is,natural%20gas%20production%20in%202019.

Figure 4.2 Shale Production by Country



Source: GlobalData, 2020

Impact of Covid-19

4.8 The global oil and gas industry has been impacted by the economic consequences of Covid-19. The effect has been particularly harsh on the already strained shale industry in the US. The decline in demand and subsequent global oil glut has left parts of the shale industry in financial stress. Many wells in the US have been made uneconomic due to the sharp fall in the oil and gas prices[22]:

- Several producing wells in the US shales were shut down in 2020 due to reduced global demand and low oil prices. The rig count in major US shale plays dropped considerably from 716 active rigs in January 2020, to 249 active rigs in October 2020, although rising oil and gas prices have been reflected in a modest increase in rig activity in Q1 2021.
- Several prominent shale producers have been pushed into bankruptcies (e.g., Whiting Petroleum, Chesapeake Energy, EP Energy, and Rosehill Resources - Whiting Petroleum emerged out of the bankruptcy in September 2020). For long term financial sustainability of many of the shale operations in the US, it is necessary for the price for shale oil and gas to increase.
- In addition, several major shale players have reduced their planned capital expenditure for the year 2020.

4.9 Additionally, a number of prominent equipment and service providers have also sought to reduce their exposure to the shale oil and gas sector in North America. Schlumberger, a major oil and gas service provider, has sold its US and Canadian fracking business to Liberty Oilfield Services. Several major service providers, such as Baker Hughes and Weatherford International, have already ceased their US shale fracking operations.

[22] GlobalData, 2020, Thematic Research, Shale.

UK Perspective

4.10 The UK has a long history of small scale conventional onshore oil and gas development. UKOOG data indicates that[23]:

- Around 2,000 wells have now been drilled in the UK (around 10% of them having been hydraulically fractured)
- Currently around 120 sites are in production, with 250 operating wells producing between 20,000 and 25,000 barrels of oil equivalent per day.

4.11 However, the UK has a very limited track record of exploration for unconventional oil and gas with no commercial production. Nevertheless, the UK also has substantial volumes of prospective shale gas and oil resources within shale formations distributed across the country. According to the EIA world shale resource assessment in 2013 there are 25.8 trillion cubic feet of wet shale gas and 0.7 billion barrels of tight oil in the UK[24]. Shale gas exploration is its infancy in the UK and has stalled following the introductions of moratoria in England, Scotland and Wales, and therefore the amount of recoverable shale gas remains highly uncertain[25].

4.12 In terms of the main locations, the UK's shale gas formations include:

- County Fermanagh, Northern Ireland
- Bowland Shale, Northern England
- Midland Valley, Scotland
- Weald Basin, Southern England
- Lower Palaeozoic rocks in Wales and central England.

4.13 Whilst the volume of shale gas and oil that is economically recoverable is yet to be estimated for the UK, in 2013 the then Prime Minister David Cameron stated that if 10% of known resources could be extracted, it would provide the equivalent of the UK's total gas needs for 51 years (based on the BGS's survey of the Bowland Shale formation[26]).

4.14 In 2014 a report commissioned by the UK Government and produced by UKOOG, an industry body for the onshore oil and gas sector, claimed that 64,500 direct, indirect and induced jobs could be supported at peak [27] through the exploration and production of shale gas. There has been substantial interest in the shale opportunities in England and Scotland from companies such as Ineos, Cuadrilla and iGas.

4.15 However, there is currently a moratorium on hydraulic fracturing across Great Britain. The Welsh Government confirmed that hydraulic fracking would not be supported in Wales in December 2018. The Scottish Government confirmed its policy position of no support for unconventional oil and gas in October 2019 (i.e. a presumption against development of this type). In November

[23] https://www.ukoog.org.uk/onshore-extraction/where-we-operate

[24] https://www.eia.gov/analysis/studies/worldshalegas/pdf/UK_2013.pdf

[25] LSE, 2020, https://www.lse.ac.uk/granthaminstitute/explainers/what-potential-reserves-of-shale-gas-are-there-in-the-uk/

[26] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/226874/BGS_DECC_BowlandShaleGasReport_MAIN_REPORT.pdf Andrews, I.J. 2013. The Carboniferous Bowland Shale gas study: geology and resource estimation. British Geological Survey for Department of Energy and Climate Change, London, UK.

[27] Ernst & Young for UKOOG 'Getting ready for UK shale gas' http://www.ukoog.org.uk/images/ukoog/pdfs/Getting_ready_for_UK_shale2_gas_FINAL2022.04.14.pdf

2019, the UK Government announced that it would take a presumption against issuing any further consents for unconventional development in England[28] in response to the uncertainty around the risks of seismic activity (following induced seismicity resulting from fracking at Cuadrilla's Preston New Road site in Lancashire). The Republic of Ireland is also intending not to issue any further licences for onshore exploration and production.

Rest of Europe

4.16 Within the EU, other countries are seeking to develop UOG resources further. According to the EIA assessment Europe[29] has 906.8 trillion cubic feet of shale gas and 93.2 billion barrels of shale oil. However, the majority of this is found in Eastern Europe, especially in Russia.

Potential Resources in Northern Ireland

4.17 Exploration for onshore oil and gas in Northern Ireland began in 1965 and whilst oil and gas shows have been encountered they have never been discovered in commercial quantities. Despite this initial lack of success to date, there remains the prospect that commercial quantities of oil and gas may be identified across Northern Ireland's basins. The source of evidence of the prospectivity includes various assessments by GSNI[30].

4.18 The basins which offer the most prospects for commercial extraction are in the Lower Carboniferous rocks of counties Fermanagh and Tyrone (the Lough Allen Basin, see Figure 4.3) and the Carboniferous to Triassic rocks beneath the NE of Northern Ireland (see Figure 4.4). The Lough Allen Basin has a history of gas shows from a small number of vertical exploration wells although the prospectivity is reduced by the poor quality of the low permeability tight gas sandstone reservoir targets drilled. In recent years the focus in the basin has shifted towards shale gas reservoirs although the use of horizontal drilling to produce gas from the tight sandstones has been proposed. Exploration in the latter is more challenging because of a thick cover of basalts above the sedimentary basins but the 2008 Ballinlea No. 1 well in the Rathlin Basin had significant gas shows, and oil samples were brought to the surface from Carboniferous conventional reservoir rocks.

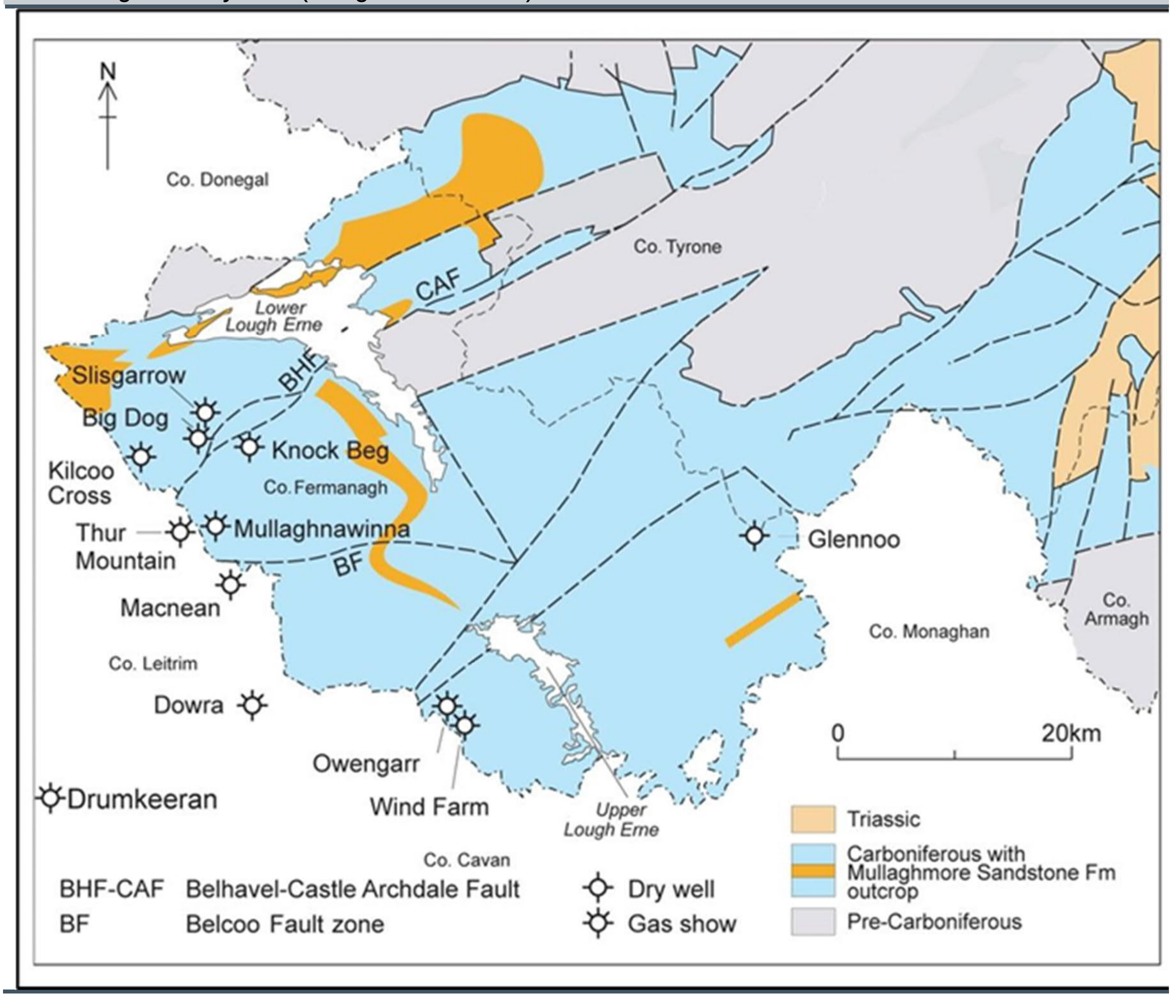
4.19 The latter area comprising Carboniferous to Triassic rocks in the NE of Northern Ireland, largely beneath the Antrim Plateau are comparatively less well explored, in part due to the technical difficulties of imaging the geological structures beneath the thick cover of Palaeogene basalt lavas. Seven exploration wells and two stratigraphic boreholes were drilled between 1971 and 2016, with traces of both oil and gas discovered in some wells and a small quantity of oil recovered to surface by the Ballinlea No. 1 well in 2008. The geology in this part of NI has many similarities to that of the East Irish Sea Basin which hosts the giant Morecambe Bay gas field, and other smaller conventional oil and gas fields.

[28] https://commonslibrary.parliament.uk/research-briefings/sn06073/

[29] Bulgaria, Lithuania/Kaliningrad, Poland, Romania, Russia, Turkey, Ukraine, Denmark, France, Germany, Netherlands, Norway, Spain, Sweden and United Kingdom.

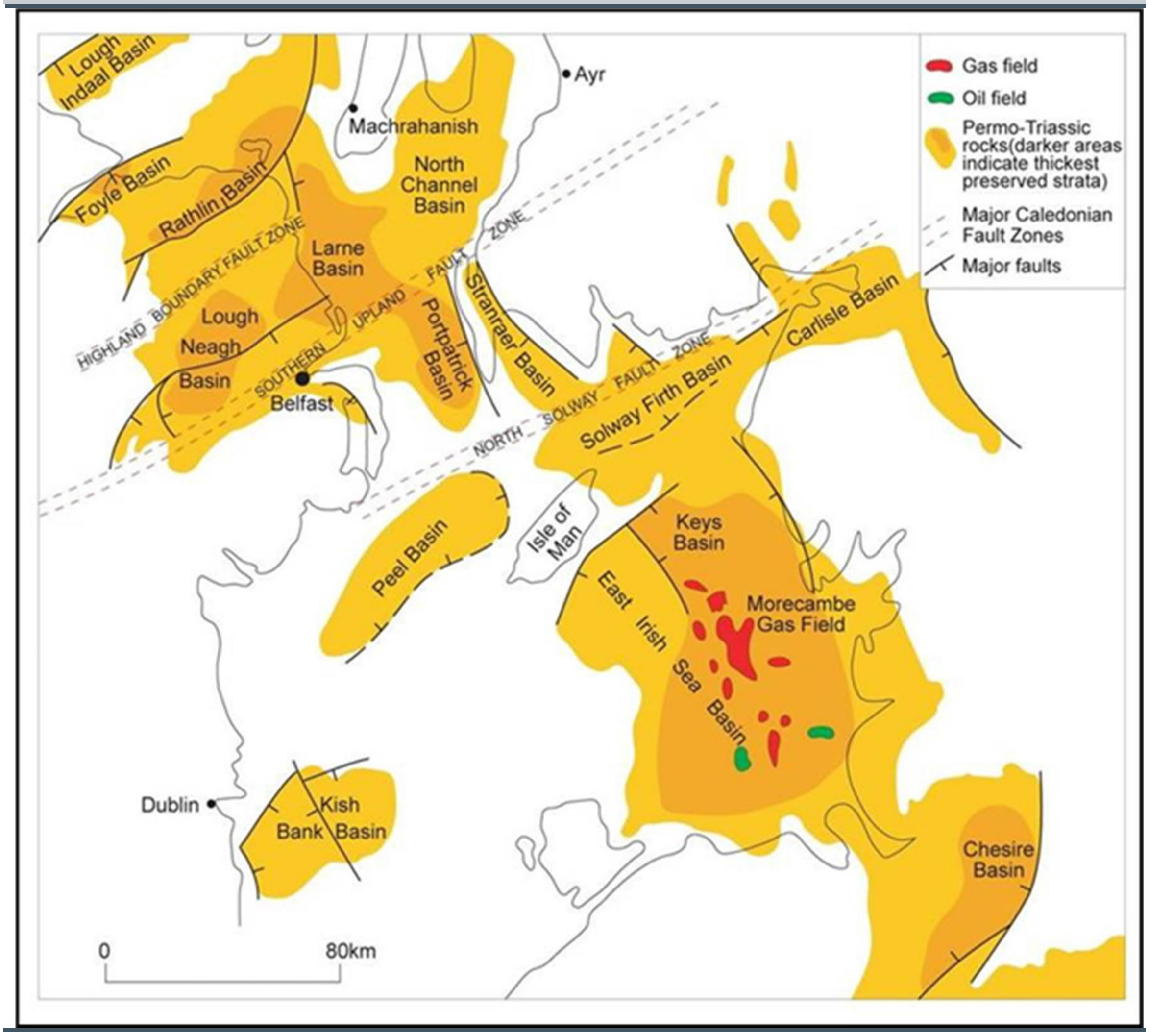
[30] The Hydrocarbon Prospectivity of Northern Ireland's Onshore Basin, Geological Survey of Northern Ireland, June 2010

Figure 4.3 Main Oil and Gas Resource Locations in the Lower Carboniferous Rocks of Fermanagh and Tyrone (Lough Allen Basin)



Source:http://earthwise.bgs.ac.uk/index.php/PostVariscan_deformation_and_basin_formation,_Northern_Ireland

Figure 4.4 Main areas prospective for conventional oil and gas in Carboniferous to Triassic rocks, NE Northern Ireland



Source:http://earthwise.bgs.ac.uk/index.php/PostVariscan_deformation_and_basin_formation,Northern_Ireland

Lower Carboniferous rocks of Co. Fermanagh and South Co. Tyrone

4.20 The Carboniferous outcrop that covers much of County Fermanagh and parts of County Tyrone, in the southwest of Northern Ireland, forms part of the larger Northwest Irish Carboniferous Basin (NWICB) which extends into the Republic of Ireland.

4.21 The NWICB contains a number of sub-basins (Lough Allen, Kesh-Omagh, Slieve Beagh basins) with distinct characteristics. The most important basin, in terms of petroleum prospectivity, is the Lough Allen Basin which straddles the border between Northern Ireland and the Republic of Ireland. This has been the focus of most of the exploration to date.

4.22 The main petroleum play in the NWICB involves source rocks (marine mudstones) and reservoir rocks of Lower Carboniferous age. The Benbulben and Bundoran Shale formations are believed to have generated large quantities of both oil and gas in the basin. The main reservoir intervals occur in the 'tight' Mullaghmore and Dowra Sandstone formations, with secondary but largely untested potential in older early Carboniferous sandstones. The Bundoran and Benbulben Shale formations both contain shale gas across large areas of the basin, although the Benbulben Shale Formation is too shallow for this gas to be extracted.

Exploration History

4.23 The Lough Allen Basin extends across the border into the Republic of Ireland and has been the focus of most of the hydrocarbon exploration activity in the NWICB. Twelve verticals wells have been drilled in the whole basin and most have encountered uneconomic gas shows to date. The Dowra sandstone was hydraulically fractured in the Dowra No.1 well in 1981 which resulted in increased, but still non-commercial, gas flow rates. In 2002-3 the shallower tight gas Mullaghmore sandstone was fracked in several wells and extended well tests performed but none of these wells sustained commercially viable gas flow rates.

Key Points

4.24 The 2010 GSNI prospectivity study concludes:

- The NWICB has the potential to become a productive 'tight gas sandstone' basin if areas of enhanced porosity/permeability can be targeted and the reservoir intervals are drilled horizontally and then fractured.
- The Mullaghmore Sandstone formation has been the main target to date but it may be that the deeper, more geographically restricted, reservoir intervals (Dowra, Boyle and Kilcoo sandstones) have the greater potential.
- Earlier exploration programmes have only partially evaluated the hydrocarbon potential of the basin, and doubts have been raised about the test results obtained because of possible formation damage and the techniques used. The small number of wells means that many areas and play concepts have not been adequately evaluated.
- Seismic data acquisition has been restricted to the Lough Allen Basin and the area to the east, including the Slieve Beagh Basin, is relatively underexplored.
- There may be only a small area in this basin where the Mullaghmore Sandstone Formation is prospective but the lower reservoir targets may have greater potential in this basin.
- Future exploration programmes should target areas of better reservoir quality where fracture porosity and sedimentary facies-dependent higher porosity zones may be present.
- Enhanced fracturing close to major fault zones may also allow a fractured gas shale play in the Bundoran and/or Benbulben Shale formations to be tested. The combination of improved exploration well targeting and the use of horizontal drilling and appropriate fracturing techniques offers the best opportunity for success.

Lough Neagh Basin

4.25 The Lough Neagh Basin is the deepest and possibly the most prospective of the Permo-Triassic basins in Northern Ireland.

Exploration History

4.26 There has been little exploration for hydrocarbons with only one licence, PL9/88, leading to 2D seismic acquisition and the drilling of two wells south of Toome near the northwest shores of Lough Neagh.

4.27 In addition, a small number of deep boreholes have been drilled for mineral exploration or stratigraphic purposes near the margins of the basin but none in the deepest parts in the northeast and southwest, or under Lough Neagh itself. These boreholes have proved the general succession but also highlighted the problems of determining the presence of an Upper Carboniferous succession (for the most important source rocks) and Permian (one of the principal reservoir intervals) because of the effects of differential uplift and erosion between fault blocks.

Key Points

4.28 The GSNI prospectivity study concludes:

- Overall, the Lough Neagh Basin has significant potential to become a productive petroleum basin. Reservoirs and caprocks exist at several stratigraphic levels including the regionally important Sherwood Sandstone Group/Mercia Mudstone Group reservoir/seal combination.
- Upper Carboniferous source rocks are known from the Dungannon/Coalisland area to the west of Lough Neagh and, although in some fault blocks these strata have been removed by erosion associated with Variscan tectonism, they are predicted to be present in the deeper parts of the basin.
- The oil show in the Annaghmore No. 1 well and hydrocarbons detected in soil and water well geochemical surveys provide support for the presence of mature source rocks in the basin.
- Several episodes of uplift and erosion may be inferred from the major unconformities and associated missing stratigraphy within the basin, and estimates of the section removed can be made from a study of fission track and sonic/density log data.
- Maturation modelling from the resulting burial history indicates that the source rocks probably started generating hydrocarbons prior to the mid Jurassic to late Cretaceous uplift phase. Compression during the phases of uplift has led to the formation of anticlinal structural traps and faulting has provided migration pathways. There is a risk that traps have been breached, with leakage of hydrocarbons to the surface, when faults have been reactivated during subsequent extensional or transtensional stress regimes but it is anticipated that some structures will have retained their integrity since being charged with hydrocarbons.
- There have been no petroleum licences in the basin since the GSNI study was published but an area around the south and east of Lough Neagh is included in a licence application submitted to DfE.

Larne Basin

4.29 The onshore Larne Basin is part of a larger basin which extends offshore under the North Channel between Northern Ireland and Scotland. The basin is deeper offshore where a significant area of the potential Carboniferous source rocks might be mature for gas. Onshore, the ENE-WSW trending Sixmilewater Fault divides the basin.

4.30 South of the fault the Permo-Triassic sequences shallow towards Belfast Lough, and thin Lower Carboniferous Upper Permian and Triassic sections crop out on the southern shore of the lough. The Permo-Triassic sequence also thickens rapidly as it deepens northwards towards the Sixmilewater Fault in the Larne area. North of the Sixmilewater Fault the Permo-Triassic tends to thin to the north and west, although in the hanging wall west of the Ballytober Fault it may reach thicknesses similar to that in the Larne area.

Exploration History

4.31 Four petroleum exploration wells and two shallower stratigraphic boreholes have been drilled in the basin since 1971. Three additional deep boreholes drilled in search of salt deposits or geothermal energy have expanded the knowledge of the geology of the basin.

Key points

4.32 The GSNI prospectivity study concludes:

- The dry Ballytober No. 1 well tested the early Permian and Sherwood Sandstone Group targets on largest structural closure mapped in the Larne Basin north of the Sixmilewater Fault. Cairncastle No.1 was drilled into the top of the Sherwood Sandstone Group on a small pop-up structure on the eastern flank of the Ballytober Horst without success. However, the seismic data coverage in the area north of the Sixmilewater Fault is incomplete and static corrections are difficult to apply, so that further prospective structures may remain to be mapped in this area.
- West of the Ballytober Horst there is potential in the hanging wall of the Ballytober Fault, where the reservoir facies in the Permian and Triassic sandstones may be better developed. South of the Sixmilewater Fault there is very little seismic data and the structure remains largely unknown.
- The strata rise southwards towards Belfast Lough but as far south as Newmill No. 1 there is still a Permo-Triassic sequence thick enough to contain oil or gas accumulations. Local reversals of the regional dip, or faults throwing down to the south, may produce structural traps in this area. The minor gas show recorded from the early Permian sandstones in the Larne No. 2 geothermal exploration borehole is an encouraging indication that there might be a viable petroleum system in the basin.
- The Carboniferous is unproven in the onshore Larne Basin although dipping reflectors below the early Permian are probably of this age. There is potential for both mature source rocks and reservoir rocks in the Carboniferous, if rocks similar to those along strike in Ayrshire are present in the Larne Basin. Disparities between the Permo-Triassic depth maps and the gravity anomaly trends suggest a variable thickness of older sedimentary rocks in the basin.
- Since 2010 there has been one further exploration licence in the Larne Basin. PL1/10 extended from Islandmagee in the east to the northeast corner of Lough Neagh in the west. Seismic reflection surveys identified a number of prospects and in 2016 the Woodburn Forest No. 1 well was drilled to test one of these. Both the Triassic and Permian sandstone targets were water-wet and the well was drilled to 2000m without reaching the Carboniferous.

Rathlin Basin

4.33 The Rathlin Basin is a northeast-southwest orientated half graben-(younging to the southeast).style basin that extends offshore to the northeast beneath Rathlin Island and the Malin Shelf. The Rathlin Basin thickens towards the southeast where it is bounded by the Tow Valley Fault. Onshore, the basin is partially covered by Palaeogene basalts which comprise the surface geology whereas offshore the basalts are largely absent and rocks of Triassic to Cretaceous age crop out at the sea bed (younging to the southeast). The Foyle sub-basin forms the north western part of the basin and deepens towards the Lough Foyle Fault.

Exploration History

4.34 Only two deep boreholes have been drilled in the Rathlin Basin, with another in the Foyle sub-basin. The Port More borehole was drilled for the Northern Ireland Government in 1967 on a gravity low, as a stratigraphic test intended to prove the extension of coal-bearing Carboniferous strata seen in the Ballycastle coalfield, and terminated at a depth of 1897 metres (-1794 metres OD) in Permian sedimentary rocks. No hydrocarbon shows were recorded but the borehole proved a thick succession of Lower Jurassic and Permo-Triassic rocks below a relatively thin succession of Palaeocene basalts and Upper Cretaceous chalk. No salt was found in a thick Triassic Mercia Mudstone Group sequence (~650 metres). The Carboniferous target was not reached before TD, but the Permo-Triassic sequence included a thick sandstone sequence with good quality reservoir rocks.

4.35 The 2008 wildcat well Ballinlea No. 1 was drilled to test a structural target identified by combined seismic and gravity interpretation and drilled to a depth of 2650 metres. Numerous gas shows were recorded from Carboniferous coals and two oil-bearing sandstone units were tested, with a limited amount of oil recovered to the surface. The well did not flow to surface and it was plugged and abandoned, although this well did prove the existence of a petroleum system in the basin.

Key points

4.36 The GSNI prospectivity study concluded:

- The Rathlin Basin is considered to have potential for oil and gas accumulations in structural traps in Permo-Triassic reservoirs, sealed by mudstones of the same age. There is a possibility that alluvial fan sands may be draped against the Tow Valley Fault if this formed a fault scarp in the Permo-Triassic. Stratigraphic and structural traps may then have been formed by lateral facies variation and differential compaction between the fan sands and the finer inter-fan and distal deposits.
- There is additional potential for discoveries in Carboniferous sandstones in both structural and stratigraphic traps. The mixed clastic sequence present in the Ballycastle coalfield provides a close spatial relationship between source, reservoir and caprocks in which oil and gas accumulations may occur, if repeated in the Rathlin Basin. (A sedimentary sequence similar to the one in the Ballycastle coalfield, complete with gas-bearing coals, oil-bearing sandstones and oil-rich shales, had been proven by the Ballinlea well but the results were still confidential when the report was written).
- The main exploration risks are the difficulties of mapping prospects because of the poor seismic data quality, and the potential for structural traps to be breached after they have been charged with hydrocarbons during subsequent tectonic episodes.
- The acquisition and integration of other geophysical data (gravity, magnetic, magnetotelluric) into the processing and interpretation stages of the seismic method should improve both the seismic imaging and the robustness of the modelling of the petroleum systems in the basin.

- The organic-rich mudstones of the Murlough Bay Formation may also have potential for shale gas production. They are known to be mature and have a high organic content. However, the poor seismic imaging currently available means that the geological structure cannot be determined with sufficient resolution or confidence for high volume hydraulic fracturing of the shale to be approved, irrespective of any other regulatory issues.
- The operator of the PL3/10 licence proposed drilling an updip appraisal well on the Ballinlea structure but withdrew from the licence, citing the lengthy planning process as a major reason for their decision not to proceed with the second well. Petroleum Licence PL5/10 covered Rathlin Island itself and the Licensee also operated a Licence issued by OGA for the area offshore Rathlin. Both the DfE and the OGA licences were relinquished after the completion of geophysical studies but without drilling.

Summary

- The concealed basins of Northern Ireland can be demonstrated to have many of the elements needed for a productive petroleum province. They show a number of similarities to productive basins elsewhere in the UK, such as the East Irish Sea Basin. Regional-scale reservoirs and seals are present in the Triassic Sherwood Sandstone Group and Mercia Mudstone Group, respectively.
- Mature oil and gas prone Carboniferous source rocks are interpreted to be present, and mature, within the deeper parts of all three basins. The main exploration play is for oil or gas trapped in the Sherwood Sandstone Group with secondary Permian reservoir targets but there is also potential for intra-Carboniferous plays including unconventional gas shale production.
- The main risks are associated with the lack of knowledge of the sub-surface structure and basin fill, and the difficulties in obtaining good quality seismic data and, therefore, producing accurate seismic two-way time and depth maps from which to identify prospects to drill. Gaps in data also introduce uncertainties about migration pathways, the relative timing of trap formation and hydrocarbon charge, and the potential for later breaching of traps.
- However, improved data should reduce these risks and determine whether this area can become a productive petroleum province. The concealed basins of northeast Northern Ireland remain an under-explored area with significant conventional hydrocarbon exploration potential.

History of Petroleum Licensing in Northern Ireland

4.37 Onshore petroleum exploration has taken place over a number of decades across Northern Ireland, although on a relatively small scale. Only 16 exploration wells and two shallower stratigraphic boreholes have been drilled under petroleum licences and although several wells have recorded gas and oil shows, none of these have led to field development and commercial extraction. Table 4.1 below summarises the history of petroleum licensing and exploration in Northern Ireland.

Table 4.1 Northern Ireland Petroleum Exploration History

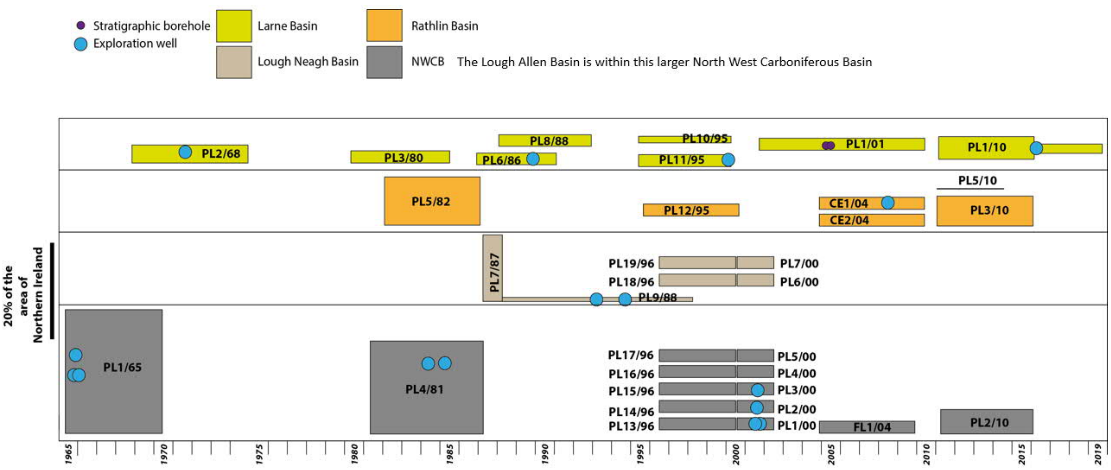
Operator	Licence ID	Wells (spud date)	Commencement	Expiry
Marathon Petroleum (UK) Ltd.	PL1/65	Big Dog No.1 (1965), Glenoo No.1 (1966), Owengarr No.1 (1965)	05/05/65	01/05/70
Marathon Petroleum (GB) Ltd.	PL2/68	Newmill No.1 (1971)	02/08/68	11/11/75
Energy Sources NI Ltd	PL3/80 mostly offshore		29/04/80	28/06/85
Aran Consortium	PL4/81	Kilcoo Cross No.1 (1985), Slisgarrow No.1 (1984)	01/04/81	31/03/87
BP Petroleum Development Ltd	PL(5)81		06/07/81	31/07/81
Barclay Consortium	PL5/82		19/01/82	18/01/87
Fynegold Petroleum Ltd. (then named Kirkland Resources)	PL6/86	Ballytober No.1 (1990)	01/11/86	31/01/91
NW Exploration	PL7/87		30/04/84	29/04/88
Mustang	PL8/88		01/01/88	31/12/92
Nuevo Energy Co.	PL9/88	Annaghmore No.1 (1993), Ballynamullan No.1 (1994)	30/04/88	29/04/98
Antrim Energy Inc.	PL11/95	Caincastle No.2 (2000) redrill of Cairncastle No.1	01/05/95	30/04/00
Mustang	PL10/95		01/05/95	30/04/00
Rigel Energy Corp	PL12/95		08/09/95	07/09/00
Priority Oil & Gas LLC & Susan Morris and Assoc	PL13-96		01/07/96	30/06/00
Priority Oil & Gas LLC & Susan Morris and Assoc	PL14-96		01/07/96	30/06/00
Priority Oil & Gas LLC & Susan Morris and Assoc	PL15-96		01/07/96	30/06/00
Priority Oil & Gas LLC & Susan Morris and Assoc	PL16-96		01/07/96	30/06/00
Priority Oil & Gas LLC & Susan Morris and Assoc	PL17-96		01/07/96	30/06/00
Priority Oil & Gas LLC & Susan Morris and Assoc	PL18-96		01/07/96	30/06/00
Priority Oil & Gas LLC & Susan Morris and Assoc	PL19-96		01/07/96	30/06/00
Evergreen Resources Inc.	PL1/00	Mullanawinna No.1 (2001), Slisgarrow No.2 (2001)	01/07/00	30/06/02
Evergreen Resources Inc.	PL2/00	Knock Beg No.1 (2001)	01/07/00	30/06/02
Evergreen Resources Inc.	PL3/00	Wind Farm No.1 (2001)	01/07/00	30/06/02
Evergreen Resources Inc.	PL4/00		01/07/00	30/06/02
Evergreen Resources Inc.	PL5/00		01/07/00	30/06/02
Evergreen Resources Inc.	PL6/00		01/07/00	30/06/02
Evergreen Resources Inc.	PL7/00		01/07/00	30/06/02
Antrim Resources (NI) Ltd.	PL1/01	Drumcrow Crossroads (2005), Salmon Hatchery (2005) (both shallow)	17/10/01	28/05/10
Connaught Energy (Alberta) Corp	CE1/04		31/12/04	28/05/10
Connaught Energy (Alberta) Corp	CE2/04	Ballinlea No.1 (2008)	31/12/04	28/05/10
Finavera Ltd.	FL1/04		01/12/04	31/11/2009
Tamboran Resources Pty Ltd.	PL2/10		01/04/11	30/09/14
P.R. Singleton Limited (Providence Resources plc)	PL5/10		22/02/11	31/07/14
Rathlin Energy Limited	PL3/10		15/02/11	14/01/16
Infrastrata plc and eCORP Oil & Gas UK Limited	PL1/10	Woodburn Forest No.1 (2016)	04/03/11	active

Source: Department for the Economy Northern Ireland, 2020.

4.38 Figure 4.5 shows the timeline of licences and wells in Northern Ireland. From 1965 to 2019:

- The Larne Basin has been subject to eight licences, four exploration wells (the most recent well, Woodburn Forest No. 1 was drilled in 2016) and two stratigraphic boreholes
- The Rathlin Basin has been subject to six licences with one exploration well
- The Lough Neagh Basin has been subject to six licences and two exploration wells
- The North West Carboniferous Basin / Lough Allen Basin has been subject to 14 licences and nine exploration wells.

Figure 4.5 Timeline of Licences and Wells in Northern Ireland



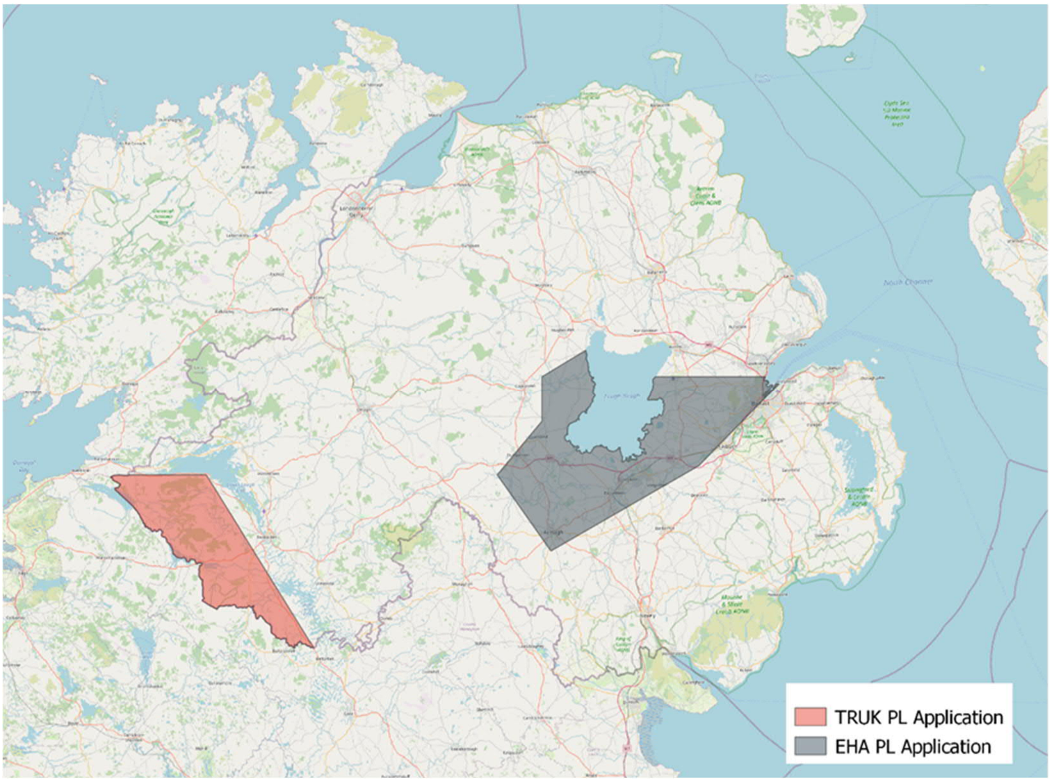
Source: Department for the Economy Northern Ireland, 2019

4.39 Most recently, in 2020, the petroleum licence (PL1/10) under which drilling of Woodburn Forest No.1 well was undertaken was relinquished, leaving no active petroleum licences held in Northern Ireland.

Current Licence Applications

4.40 There are two current petroleum licence applications in Northern Ireland: PLA1/16 (EHA application) which is located around the southern half of Lough Neagh and PLA1/16 (TRUK application) which is in the South West of Northern Ireland bordering the Republic of Ireland. Both application areas cover a significant area of Northern Ireland. The map in Figure 4.6 shows the geographical area covered by the two onshore petroleum licences currently proposed. The area covered by the EHA petroleum licence application is approximately 1,666 km^2, whilst that covered by the TRUK petroleum licence application is approximately 607 km^2.

Figure 4.6 Current Applications for Onshore Petroleum Licences in Northern Ireland



Source: OpenStreetMap, Department for the Economy Northern Ireland, 2020.

4.41 The Department for the Economy carried out public consultation in respect of two Petroleum Licence Applications - PLA1/16 and PLA2/16. The public consultations began on 07 May 2019 and closed on 31 July 2019. The Department received a total of 5,703 responses: 2,572 for PLA1/16 and 3,131 for the PLA2/16[31]. The Department for the Economy identified eight campaign letters regarding the EHA application, which together account for a total of 2,274 responses. In addition, the Department for the Economy identified eight campaign letters regarding the TRUK application, which together account for a total of 2,274 responses. The main themes of the campaign letters are summarised in the table below.

[31] https://www.economy-ni.gov.uk/articles/petroleum-licence-applications-pla116-and-pla216-consultation-responses

Table 4.2 Summary of recent petroleum licence consultation responses

Name of Campaign Letter	Summary of Response
	Licence Application PLA1/16 (EHA Application)
People Before Profit	The respondents object to plans to drill for petroleum in Greater Belfast due to the potential risk to communities including potential for habitat destruction, petroleum leakage and the possibility for water contamination, as well as the opinion that fossil fuels should remain in the ground due the overall impact on the local environment and contribution to climate change.
Friends of the Earth	The respondents indicated that granting the licence would contradict science, law and policy and further deepen Northern Ireland's climate debt by tying the country into a 30-year dependency on fossil fuels. They commented on the high environmental and health risks, whilst noting that development will support only a small number of highly skilled jobs beyond the construction period. In addition, they note the economic potential for promoting a green and circular economy to lead to better sustainable local job opportunities than oil and gas development.
Lough Neagh Fishermen	The respondents object in the strongest possible terms. A key concern is that a decision could be taken without appropriate environmental, health or economic risk assessment. They also note that the problem of leaky wells and wastewater disposal is, in their view, unsolved. The issue of earthquakes also highlighted. They note the economic value of tourism around Lough Neagh providing leisure and health benefits as well as being important culturally and historically. The Lough is a RAMAR site and provides a significant level of drinking water and is important to the fishing industry.
Residents	The responses included objections from South Lough Neagh Residents, ABC Council Area Residents, North and West Belfast Residents, who list a range of environmental, social and economic issues as the reasons for their objection.
	Licence Application PLA2/16 (TRUK Application)
Petroleum Licence Application	Their objection to development was based on the direct threat to agriculture (through spills and leaks) and tourism. The responses note that there is no certainty that fracking is not a significant risk to air and water. In addition, Methane leaks would release additional greenhouse gases. They noted that the geographical areas suggested are of high scientific value and scientific interest and include the Marble Arch Caves. They were of the opinion that fracking is not compatible with a safe climate future. In addition, there is potential for cross border impact, the Republic of Ireland have banned onshore shale gas activities.
Submission to Department	The respondents were opposed to the licence due to the risk of earthquakes and land subsidence, risk of groundwater contamination and methane emissions.
Friends of The Earth	Provided the same response as Licence Application PLA1/16 (EHA Application). Please see above.
Public Interest	The objection was based on research showing the complex geology of the area, which makes the area much more high risk than the US. These responses were of the view that net zero targets would mean that we should be moving away from oil and gas and fracking is dirty and is unsuitable for even very sparsely populated area (as in the US). The response recommends including the Republic of Ireland in consultations and following their lead in banning exploration of unconventional hydrocarbons.
30 Year Letter	The objection to a 30-year petroleum licence suggests that the licence regime needs to be assessed on whether it is fit for purpose. The concern was that there is a reluctance for an SEA to be undertaken. As well as a concern that the area borders Republic of Ireland which has a ban on fracking exploration and extraction.
Residents of Fermanagh, Leitrim and Manorhamilton	The respondents objected to the licence application. The residents felt as though there has been a lack of consultations and noted the impact on agriculture and tourism sectors and areas of outstanding beauty as reasons for objection, as well environmental concerns such as leaky wells and wastewater disposal. They noted that the employment benefit for local people would be limited. They wish the matter to be treated with the highest political seriousness.

Source: https://www.economy-ni.gov.uk/articles/petroleum-licence-applications-pla116-and-pla216-consultation-responses

Influences on Future Extraction in Northern Ireland

Uncertainty over the Resource

4.42 As noted above, there has been a long history of exploration for oil and gas in Northern Ireland although it has yet to be discovered in commercial quantities. Whilst there are a variety of factors which point to the potential of the area's basins, there are also good reasons to believe that the uncertainty over the potential resource which can be commercially extracted will remain.

4.43 The onshore oil and gas sector is a highly mobile sector, typically investing where it can secure the greatest return at lowest risk. The amount of investment needed to substantiate the commercial prospects in Northern Ireland is considerable and this investment has been limited to date. But it is only once there is an improved geological and geophysical understanding of the target formations that industry will have greater confidence over whether Northern Ireland represents an attractive area for investment.

4.44 The moratoria in the rest of the UK and the Republic of Ireland will prevent the gathering and sharing of geophysical evidence for similar basins, as well as the practicalities of securing planning and regulatory permissions and testing, drilling and operating onshore wells. The absence of this track record will not help to reduce the uncertainties that developers and investors face. A number of exploration wells have been drilled for conventional targets in Northern Ireland and any future exploration of this type would not be dependent on the results and experience from elsewhere in the UK and Ireland – the risks and uncertainties relate to the knowledge of the local geological subsurface in the concealed sedimentary basins of NE Northern Ireland.

4.45 A House of Lords Economic Affairs Committee examined the prospects for the UK's shale oil and gas industry in 2014. A number of contributors expected the industry to be operating at scale in GB by the early to mid-2020s, which it clearly is not. The absence of this development elsewhere in the UK will make the shale gas development in Northern Ireland a much harder step to take than would otherwise have been the case.

Market and Investment Factors

4.46 Although highly uncertain, it is possible that global prices remain low as demand for oil and gas falls as part of the transition to a zero-carbon economy. Whilst this scenario would reduce the prospects for onshore development in Northern Ireland being financially viable (given higher costs compared to US shale production), it is uncertain due to the range of global economic and geo-political factors which will influence this.

4.47 Factors that could increase the stimulus for development include energy shocks which push energy prices up and global political pressures affecting energy markets which encourage governments to seek greater energy security.

4.48 The focus of policy on decarbonising energy is placing considerable pressure on major oil and gas operators to diversify away from fossil fuels to renewable energy sources. Whilst this is being underpinned by a massive flow of investment capital away from oil and gas projects and into renewables projects, there could still be an interest from smaller developers in pursuing onshore development opportunities (subject to market prices and the policy environment).

Social Licence to Operate

4.49 The social licence to operate exists where a project has the ongoing approval within the local community and other stakeholders to be implemented and to continue to operate. As noted earlier, the initial shale gas exploration and production wells which were planned in Great Britain ahead of the fracking moratoria, would have provided opportunities to address directly issues concerning the public acceptability of hydraulic fracturing. This includes gathering the evidence relating to the main concerns for communities and interest groups (including induced seismicity, surface and groundwater quality, water resource availability, treatment of produced water, fugitive emissions, traffic movements, noise and vibration, and visual intrusion).

4.50 In theory at least, it is only when the technologies can be demonstrated to operate safely in environments and planning regimes similar to Northern Ireland, that the level of controversy associated with these developments will diminish and developers secure the social licence to operate. However, in practice this may be difficult to achieve given the moratoria in GB and the shift away from onshore oil and gas extraction elsewhere in Europe given the climate emergency.

Summary

4.51 Commercial exploration and production of onshore shale oil and gas has been particularly advanced in United States and Canada[32], accounting for much of the global output to date. The shale gas production increased from 18.6 trillion cubic feet (tcf) in 2017 to 25.3 tcf in 2019 (i.e. 75% of total U.S. dry natural gas production in 2019[33]). The growth in the US has been driven by the combination of substantial reserves, advances in horizontal drilling and hydraulic fracturing, and favourable development conditions. These favourable circumstances in the US which are favourable to large scale production include private ownership of sub-surface rights, a large number of independent operators, extensive supply chains, a skilled workforce, and an existing pipeline and supporting infrastructure (due to the presence of a well-established conventional oil and gas sector).

4.52 The UK has substantial conventional and unconventional resources which could potentially be accessed through onshore exploration and extraction. Despite the increase in interest from the industry and UK Government over the last 15 years, there remains considerable gaps in the engineering, geological or cost information necessary to make a meaningful estimate of overall technically recoverable shale gas resources.

4.53 Exploration for onshore oil and gas in Northern Ireland began in 1965 and whilst oil and gas shows have been encountered they have never been discovered in commercial quantities. The basins which offer most prospects of commercial extraction are in the Lower Carboniferous rocks the counties of Fermanagh and Tyrone and the Carboniferous to Triassic rocks beneath the Antrim Plateau. The former has a history of gas shows from a small number of exploration wells but the prospectivity for conventional oil and gas is reduced by the poor quality of the low permeability tight gas sandstone reservoir rocks and incomplete knowledge of the gas content of the shale reservoirs. The latter have potential for conventional oil and gas accumulations and,

[32] United Nations Conference on Trade and Development, Commodities at a glance, Special issue on shale gas. 2018.

[33] https://www.eia.gov/tools/faqs/faq.php?id=907&t=8#:~:text=How%20much%20shale%20gas%20is,natural%20gas%20production%20in%202019.

although exploration is technically challenging, a working petroleum system has been demonstrated in the Rathlin Basin by the 2008 Ballinlea No. 1 well.

4.54 Only eighteen exploration wells have been drilled and although several wells have recorded gas and oil shows, none of these have led to field development and commercial extraction. Despite this initial lack of success to date, there remains the prospect that commercial quantities of oil and gas may be identified across Northern Ireland's basins. However, it is subject to considerable uncertainty

4.55 The two current licence applications within Northern Ireland, which are currently on hold due to the review of the petroleum licensing regime, have faced considerable opposition from politicians, local communities and interest groups.

4.56 Although it is feasible that commercial quantities of oil and gas could be identified, it is nevertheless highly uncertain that this could occur in practice due to the following factors:

- There is considerable uncertainty about the presence of oil and gas resources in NI and the exploration which has occurred to date has provided little data to reduce this uncertainty. The absence of this intelligence makes future investment highly speculative and the potential economic return lower. However, the fact that DfE has received two licence applications within the past five years indicates that there is still some industry interest in Northern Ireland.
- The moratoria in Great Britain and Republic of Ireland will limit new research into the nature and prospectivity of the shale gas resource and the development of an onshore unconventional oil and gas sector which could be relevant to NI. This will in turn limit the sharing of knowledge and expertise and the development of supply chains which help to de-risk investments in NI and reduce development costs.
- Although highly uncertain, it is possible that oil and gas prices remain low as demand for oil and gas falls as a result of the transition to a zero-carbon economy. Whilst this scenario would probably reduce the prospects of onshore development in Northern Ireland being financially viable (given higher costs compared to US shale production), it is highly uncertain due to the range of global economic and geo-political factors which will influence this.
- Proposed onshore development in Great Britain and Northern Ireland, especially hydraulic fracturing, has faced considerable opposition from interest groups and local communities. In practice it may be increasingly difficult to overcome this opposition and to achieve the social licence to operate. Although opposition has been primarily directed towards the use of fracking for shale gas and oil, opposition seems to be growing against any further exploration and development of petroleum resources of any type. This opposition is often framed within the context of climate change and the need to reduce the use of fossil fuels and greenhouse gas emissions.

4.57 These considerations have informed the development scenarios which are set out in Section 5. There is a recognition that whilst the development of an onshore oil and gas sector in Northern Ireland at scale is technically feasible, various factors reduce the likelihood of this happening in practice (including technical, market, financial and social considerations). These factors could in turn lead to a lower level of activity taking place in the future, a continuation of the situation over the last two decades which has seen intermittent but ultimately unsuccessful exploration, or even no further exploration (which defines the No Development scenario).

5. The Development Scenarios

Introduction

5.1 This section of the report sets out the approach to estimating the potential environmental, social and economic impact of future onshore development of conventional and unconventional oil and gas resources in Northern Ireland.

5.2 Given the considerable uncertainty over the likely development path of onshore petroleum exploration and extraction in Northern Ireland, a range of possible development scenarios have been used to test the potential impacts of various development paths. The scenarios take account of the publicly available information on the possible type, scale and location of the resource within Northern Ireland. They also take account of the consequences of the moratoria which have been implemented in the rest of the UK (through for example the removal of the opportunities to share data between well developments and to enhance supply chains), as well as the more recent policy position of the Republic of Ireland Government. It is assumed that the current planning policy and regulatory regime for onshore petroleum development in Northern Ireland remain in place (although it is recognised that the Northern Ireland Executive may wish to amend these in the future as part of the policy development process).

The Development Scenarios

5.3 Given there is little information available on the technically recoverable resource in Northern Ireland, the scenarios have been based on different scales of activity which are judged to be feasible given the current NI policy and the overall assessment timescale. However, as explained below, there are different likelihoods of these development scenarios occurring in practice:

- No development scenario – this scenario assumes that no exploration or commercial exploitation takes place in NI over the next three decades. Whilst unlikely to arise over the assessment period under NI's prevailing policy position, it is feasible that it could occur if the uncertainty and risk facing the sector were to increase. The purpose of including this scenario is to enable comparison to the other three scenarios which include some amount of development.
- Low development scenario – uncertainties and other barriers to widespread development remain and global energy prices continue to provide limited incentives to invest in Northern Ireland. A higher level of exploration is assumed to occur which leads to successful commercial scale production of both conventional and unconventional resources, although still on a fairly limited basis. The potential likelihood of the scenario and its associated level of activity occurring under NI's prevailing policy is considered to be moderately high.
- Medium development scenario – A number of the barriers and aspects of uncertainty affecting the industry are lessened or removed, in part through a higher level of exploration. Higher energy prices may provide a greater incentive to development compared to the low scenario. There is a step change in exploration and production compared to the low scenario. The potential likelihood of this scenario and its associated level of activity occurring under NI's prevailing policy is judged to be moderate.
- High development scenario - uncertainty affecting the industry is greatly reduced in Northern Ireland possibly through more supportive policy and regulation and a higher

level of successful exploration and deployment of commercial wells which helps to delineate the recoverable resource and associated risks. Activity could also be stimulated by market factors such as a much higher increase in energy prices which are sustained in the longer term. This leads to a significant step change in commercial extraction, stimulating significantly higher investment activity across Northern Ireland's basins. The potential likelihood of this scenario and its associated level of activity occurring under NI's prevailing policy is judged to be low.

5.4 The scenarios are not setting out possible or preferred policy options which the Department for the Economy may consider in due course, nor do they consider the specific assumptions about future policy decisions which may shape these options.

Scenario Assumptions

5.5 Besides defining the circumstances in which the development scenarios are likely to occur in (above), they are also defined in terms of their indicative scale (i.e. number of pads or developments, number of wells per pad, number of laterals), the type of well (i.e horizontal drilling with hydraulic fracturing or vertical drilling), (the resource type and location (i.e. conventional or unconventional and the basin in which development may occur).

5.6 These assumptions provide a basis for the quantification of economic impacts, as well as a range of additional exploration and production related variables (e.g. water and waste requirements, methane flares, HGV movements, etc) which will inform the environmental and social assessment. There is evidence to help inform these assumptions from other economic and strategic environmental assessments (although this evidence can often be vague and opaque in their definition of their assumptions) and site specific EIAs in the UK (as well as monitoring data for US sites, although much of this evidence is already factored into the UK SEAs).

5.7 The basis of the development scenarios – scale, type and location - is summarised in Table 5.1 below.

Table 5.1 Outline of Development Scenarios

Conventional	Unconventional
High Scenario	
There are 3 main conventional basins onshore N. Ireland, Rathlin Basin (780 sq km), Larne Basin (650 sq km) and Lough Neagh Basin (888 sq km with *390 sq km* unlikely due to designations). Of these only the Rathlin Basin is well mapped, this shows 10 structures. Assuming a 1 in 5 success rate this would lead to 2 developments. As the structures are generally small and conventional, 2 wells per development have been assumed. Extrapolating this level of prospectivity to the other basins would give: Larne Basin - 2 developments of 2 Wells; Lough Neagh Basin - 1 development of 2 wells. Total Conventional: 5 well pads and 10 wells in total (av of 2 wells per pad)	The main unconventional prospect is the Bundoran Shale Formation in the Lough Allen Basin. The Bundoran Shale Formation has an extent in the subsurface of approximately 560 square kilometres. However, there are significant areas of this that would not be available for development due to shallow depth or environmental restrictions. To fully develop the areas available (allowing for development constraints) could accommodate approx. 4 well pads at 6 wells a pad. Unconventional: 4 well pads and 24 wells in total (av of 6 wells per pad)
Medium Scenario	
Conventional: 3 well Pads and 6 wells in total (av of 2 wells per pad)	Unconventional 2 well pads and 12 wells in total (av of 6 wells per pad)
Low Scenario	
Conventional: 2 well pads and 4 wells in total (av of 2 wells per pad)	Unconventional: 1 well pad and 6 wells in total
No Development Scenario	
No exploration of commercial exploitation of onshore oil and gas takes place in NI over the assessment period.	

5.8 Table 5.2 outlines the associated assumptions for the number of pads and wells for conventional and unconventional oil and gas resources.

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Table 5.2 Pad and Well Intensity by Development Scenario

	No Development	Low Development		Medium Development		High Development	
Type of Resource	Conventional/ Unconventional	Conventional	Unconventional	Conventional	Unconventional	Conventional	Unconventional
Number of pads	0	2	1	3	2	5	4
Number of wells per pad	0	2	6	2	6	2	6
Total number of wells	0	4	6	6	12	10	24
Number of laterals/sidetracks:							
Low intensity	0	8	12	12	24	20	48
High Intensity	0	16	24	24	48	40	96
Estimated output (mmboe):							
Low intensity	0	8.00	6.24	12.00	12.48	20.00	24.96
High Intensity	0	16.00	24.00	24.00	24.96	40.00	49.92

Source: Hatch; Note: low and high intensity rates for lateral drilling is defined as 2-4 horizontals respectively for both conventional and unconventional oil and gas resources. The No Commercial Production Scenario is excluded from the table as it does not include the development of a commercial scale pad development.

5.9 The available evidence from the US suggests a high intensity of activity per pad for shale oil and gas (i.e. number of well and laterals drilled per pad). This practice has informed a number of the UK studies which have assumed a high intensity of activity (i.e. 40 laterals per pad being a common place assumption made up of 10 vertical wells and four laterals per well). There is limited evidence in the UK to support this assumption and there are good reasons to assume that this intensity might not be achievable in Northern Ireland given its geology (i.e. thin formations, the style and distribution of faults, shallowness of shale formation across parts of the basin, comparatively lower number of target horizons). A more cautious approach has been adopted for this study to reflect this uncertainty (between 12 and 24 laterals wells per pad, for both conventional and unconventional resources, for the low and high intensity assumptions respectively).

Assessment Period and Development Phases

5.10 The overall assessment covers the period between 2021 and 2050, a period of thirty years. Consequently, all of the expenditure associated with the lifecycle of this additional activity is captured up to 2050. Where impacts associated with activity undertaken up to 2050 may occur beyond this time period, the assessment considers these subject to the available evidence and certainty about their nature, scale and duration.

5.11 The analysis has confirmed that the level of development activity under all of the scenarios is technically feasible within the time period considered, although the high scenario may be more challenging to achieve in practice given the need to source specialist drilling and hydraulic equipment during the earlier drilling phases (which may need to be imported where it is not present on the island of Ireland).

5.12 The indicative development cycle for a development[34] are outlined below:

- Stage 1: Surveying, site selection and planning - up to 3 years
- Stage 2: Site preparation, drilling and testing – up to 2 years
- Stage 3: Production – 10-15 years[35]
- Stage 4: Decommissioning and restoration – 6 months to a year[36].

Development Costs

5.13 Whilst there is a lot of evidence for the development, capital and production costs of wells for conventional and unconventional resources in the US, there is no similar evidence base for the UK. This is important as it is unlikely that the costs for developments in Northern Ireland will benefit from the economies of scale and hence costs savings which have been achieved in the US. Also, whilst other UK studies have assumed some degree of economies of scale can be achieved for higher development scenarios, it is also unlikely that this can be achieved in Northern Ireland given the maximum scale of activity assumed (and hence has not been built into the scenarios for this assessment).

[34] the timescales for the phases are approximate and may vary between developments of similar and different types depending on the geology and productivity of the well

[35] this may be longer for conventional wells (up to 20 years), although the productivity of these well may be significantly reduced in the later years

[36] this may also involve periodic aftercare of the well which may continue after decommissioning

5.14 Table 5.3 sets out the assumed development costs for higher and lower intensity wells (2 and 4 laterals per well respectively) by phase of development. Whilst there may be differences, for the purposes of this analysis the same costs are assumed for wells for both conventional and unconventional resources. The total lifecycle costs for a well are assumed to be £19.5m for a 2 lateral well and £24.5m for a 4 lateral well. These costs are a best estimate.

5.15 The total lifecycle development costs range from £195m-£245m under the low development scenario (with the range defined by number of laterals drilled per well), £351m-£441m for the medium development scenario, £663m-£833m for the high development scenario (see Table 5.4)

Table 5.3 Estimated Average Cost Per Well for High and Low Intensity Activity and by Phase of Development £millions

	Cost for a 4 Lateral Well	Cost for a 2 Lateral Well
Development & Exploration	2.75	2.75
Drilling	6.00	4.50
Fracturing	10.00	7.50
Waste Management	1.00	1.00
Operations	4.00	3.00
Decommissioning & Aftercare	0.75	0.75
Total	24.5	19.5

Source: Hatch analysis; 2021 prices

Table 5.4 Total Lifecycle Development and Operational Costs by Development Scenario, 2021-2050 £millions

	Low Development Scenario			Medium Development Scenario			High Development Scenario		
	Conven-tional	Uncon-ventional	Total	Conven-tional	Uncon-ventional	Total	Conven-tional	Uncon-ventional	Total
Low intensity drilling	78	117	195	117	234	351	195	468	663
High Intensity drilling	98	147	245	147	294	441	245	588	833

Source: Hatch; 2021 prices; note – the no development scenario assumes no exploration or production activity and hence is not included in this table.

Summary

5.16 Given the considerable uncertainty over the potential development path of onshore petroleum exploration and extraction in Northern Ireland, a range of possible development scenarios have been used to test the impacts of various development paths. The scenarios take account of the publicly available information on the type, scale and location of the resource within Northern Ireland. The development scenarios are not policy scenarios and it has been assumed that the prevailing policy relevant to NI does not change.

5.17 The development scenarios are:

- No development scenario – this scenario assumes that no exploration or commercial exploitation takes place in NI over the next three decades. Whilst unlikely to arise under NI's prevailing policy position, it is feasible that it could arise if the uncertainty and risk

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facing the sector were to increase. The purpose of including this scenario is to enable comparison to the other three scenarios which include varying amounts of development.

- Low development scenario – two conventional developments and one unconventional development (total of 10 wells). The potential likelihood of this scenario and its associated level of activity occurring is judged to be relatively high compared to the other scenarios.
- Medium development scenario – three conventional developments and two unconventional development (total of 18 wells).
- High development scenario - five conventional developments and four unconventional development (total of 34 wells). The potential likelihood of this scenario and its associated level of activity occurring is judged to be relatively low compared to the other scenarios.

5.18 In addition, different intensities of drilling activity have been assumed which allow for the potential of more or fewer laterals per well. The low and high intensity rates for lateral drilling is defined as 2 and 4 horizontals respectively for both conventional and unconventional oil and gas.

5.19 The overall assessment covers the period between 2021 and 2050, a period of thirty years. Where impacts associated with activity undertaken up to 2050 may occur beyond this time period, the assessment considers these subject to the available evidence and certainty about their nature, scale and duration. Also, bearing in mind that this is a high level assessment, it has not always been possible to be specific about the quantitative impacts where they may persist.

5.20 The analysis has confirmed that the level of development activity under all of the development scenarios is technically feasible, although the high scenario may be more challenging to achieve in practice given the various sources of uncertainty, lead times for securing development consents and the sourcing of specialist drilling and hydraulic equipment during the earlier drilling phases.

5.21 Whilst there may be some differences in practice, for the purposes of this analysis the same costs are assumed for wells for both conventional and unconventional resources. The lifecycle costs for a well are assumed to be £19.5m for a 2 lateral well and £24.5m for a 4 lateral well. The total lifecycle development costs (in 2021 prices) range from £195m-£245m under the low development scenario, £351m-£441m for the medium development scenario, £663m-£833m for the high development scenario. The costs have been informed by previous similar studies, engagement with industry specialists and Hatch's in-house expertise.

Part B

6. Review of Socio-economic Impact Evidence

6.1 This section considers evidence of the economic impact of onshore oil and gas exploration and production. It examines the international evidence, which is dominated by the US literature, as well as the available evidence from the UK.

US Evidence

6.2 The vast majority of global shale oil and gas (89% and 78% respectively) was produced in the US in 2019[37]. For this reason, much of the economic impact evidence is focused on the extraction of unconventional resource in the US. Also, the majority of the research evidence has been gathered at a time when the industry was expanding rapidly and hence does not take account of the adverse effect on the US shale industry of the Covid-19 pandemic. Nevertheless, the evidence provides valuable evidence around the economic benefits associated with a rapid upscaling in production activity, albeit vulnerable to major national and global economic shocks.

GVA and Employment Creation in the US

6.3 The IHS Global Insight study[38] assessed the economic impact of unconventional oil and gas exploitation to the US economy in 2012 and presented growth estimates up to 2035. The study presented the following estimates for the economic impact of unconventional oil:

- Annual capital expenditure of $87bn in 2012 and estimated to rise to £350bn per year by 2035 (£5.15 trillion in total between 2012 and 2035).
- 1.75 million jobs supported in the lower 48 US states in 2012 (split between 360,000 direct jobs, 537,000 indirect jobs in supplying industries and 850,000 induced jobs) and estimated to reach 3.5 million jobs in 2035.

6.4 The reasons for the scale of the impacts included the rapid upscaling of activity, the strength of US supply chains serving onshore development resulting in a larger proportion of expenditure retained in the US, and many of the jobs supported directly or indirectly being relatively well paid (and hence supporting many jobs in local service centres).

6.5 A 2012 review of the US unconventional oil and gas industry (Albrycht et al. 2012)[39] also found evidence of strong direct and indirect employment effects in the US. The study concluded that the majority of supply chains for the unconventional oil and gas industry are located within the US and there is very limited import of any products required for unconventional gas extraction and production.

6.6 A number of economic impact studies have been undertaken for the major unconventional oil and gas plays in the US:

[37] GlobalData, 2020, Thematic Research: Oil & Gas Shale.

[38] IHS (2013) America's new energy future: the unconventional oil and gas revolution in the US economy. Volume 3.

[40] Considine, Watson and Blumsack, 2010, The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Play: An Update.

- An assessment of the economic impact of unconventional oil and gas plays in the Appalachian basin in Pennsylvania[40] where 710 wells were drilled in 2009, estimated that around of 22,000 full time equivalent (FTE) direct jobs were supported across all sectors, with around 3,000 (14%) in the Mining Sector and 5,000 in the Construction Sector (23%). This activity also supported 8,700 indirect jobs and a further 13,600 induced jobs.
- A 2017 University of Texas at San Antonio assessment estimated that the economic impact of shale drilling in the Eagle Ford basin from 2014 to 2016. The study found that the basin produced $123 billion in economic impact and supported more than 191,000 jobs in 20 Texas counties during the height of the oil boom in 2014 when prices peaked above $100 per barrel. When crude oil prices dropped to as low as $26 per barrel in January 2016, the economic impact support also shrank significantly reaching around $49.8 billion and around 108,000 jobs during that period[41].

6.7 Studies have also sought to identify the economic contribution of unconventional oil and gas to regional economic performance. Spencer et al. (2014) found a weak positive correlation between unconventional oil and gas production and overall employment growth[42]. Weber (2012)[43] assessed the impact natural gas production had on overall job levels within counties in the states of Colorado, Texas and Wyoming. The study found that being a producing county led to higher growth in employment (1.5%) and income (2.6%), whilst $1 million in gas production generated 2.35 jobs within the counties.

6.8 The lower employment impacts in this study were in part due to the focus on county employment creation and support. Due to the leakage of expenditure out of the counties, the impacts did not include all employment associated with the development lifecycle.

Wider Economic Impacts

Energy Security

6.9 In the late 1990s and early 2000s the US was consistently a net gas importer. However, due to the commercial development of its substantial shale gas reserves, its rapid growth in natural gas exports enabled the US to be a net exporter of natural gas [44]. In 2019/2020 the US began exporting more petroleum than it imported, a shift arising from the record shale production in fields such as the Permian Basin.

6.10 However, amid the worst price fall in nearly three decades during 2020, American drillers have faced a million-barrel drop in production that has potential to set back the country's energy security gains[45]. The main threat comes from the possibility of a low oil and gas price that is sustained, making it uneconomic for shale producers in the largest US shale fields.

[40] Considine, Watson and Blumsack, 2010, The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Play: An Update.

[41] University of Texas at San Antonio Institute for Economic Development, 2017, Economic Impact of the Eagle Ford Shale: Business Opportunities and the New Normal.

[42] Spencer et al. 2014. Unconventional wisdom, an economic analysis of US shale gas and implications for the EU.

[43] Weber, 2012, The effects of a natural gas boom on employment and income in Colorado, Texas, and Wyoming.

[44] https://www.eia.gov/energyexplained/natural-gas/imports-and-exports.php

[45] https://www.worldoil.com/news/2020/3/10/are-america-s-days-as-a-net-oil-exporter-numbered

Cost of Energy

6.11 Lower natural gas prices translate into a reduction in electricity prices. The regions in the US with the highest natural gas extraction typically have the lowest electricity price[46]. This is a particularly important factor for energy-intensive businesses and can be an important factor in the locational decisions of these businesses.

6.12 Spencer et al (2014)[47] however concluded that the shale oil and gas revolution had a minimal impact on US manufacturing, confined to gas-intensive sectors. The study also estimated the average increase in the level of US GDP that is likely to occur between 2014 and 2040 as a result of greater productivity from lower gas costs. This was estimated to be in the order of 0.57% of GDP.

6.13 Frondel and Horvath (2019) investigated the effect of the increase in U.S. oil on world oil prices. The study found that there is a statistically significant negative long-run relationship between increased U.S. oil production and oil prices.

Price of chemicals

6.14 Impurities from natural gas can be extracted to produce valuable materials in the petrochemical industry (mostly C1 Methane in case of the shales of Fermanagh). Petrochemical feedstock accounts for 12% of global oil demand[48] and a large proportion of production costs for petrochemical and fertilizer producers.

6.15 Lower natural gas prices for both industrial use and electricity generation, and higher supply and a fall in production costs for feedstock, could benefit the entire value chain. This incentivises the development of projects including natural gas processing plants, fractionation capacity projects, ethane and propane projects for fertilizers etc[49].

6.16 The IHS (2013) report estimated that in 2012 employment in energy-related chemicals was more than 53,000 jobs, estimated to increase to almost 319,000 jobs by 2025. Combined with the total unconventional oil and gas value chain employment, this represented around 2% of the total US employment in the short term (2012-2015), potentially increasing to 2.4% by 2025.

6.17 The oil price crash resulting from the Covid-19 pandemic has brought mixed fortunes for the petrochemical industry. While demand for some chemicals has fallen with the shrinking world economic output, demand for others is surging. Refineries are having to adapt, if they can, and some are proving more flexible than others[50].

[46] Albrycht, 2012, The impact of shale gas extraction on the socio-economic development of regions – an American success story and potential opportunities for Poland.

[47] Spencer et al, 2014, Unconventional wisdom, an economic analysis of US shale gas and implications for the EU.

[48] IEA, 2018, The Future of Petrochemicals.

[49] University of Texas, 2014, Economic impact of the Eagle shale drilling.

[50] King, 2020, Oil price crash ripples through chemicals production. https://www.chemistryworld.com/news/oil-price-crash-ripples-through-chemicals-production/4011799.article

Local Impacts

Workforce Requirements, Training and Education

6.18 US studies indicate that the drilling of shale oil and gas development usually depends on out-of-state capital equipment and workforce, except for truck hauliers and construction workers[51]. Energy companies and contractors that perform specialist drilling and fracturing activities typically operate at a pan-state level, limiting the direct job opportunities for local residents.

6.19 A study by Cornell University[52] found that where exploration and drilling occurs at scale and over a prolonged period, there are opportunities to replace specialist 'out-of-town' workers with local employees. Local businesses are able to adapt so that they are able to participate in shale development and supply chains and hence to employ local workers. There are also more employment opportunities for local residents during the post-drilling production phase, where it is more cost effective to recruit and train local workers. These jobs are generally more readily available in local labour markets, although also fewer in number compared to earlier stages.

6.20 A more recent report analysed employers and colleges in Ohio, Pennsylvania and West Virginia in the context of developing a skilled workforce for the oil and gas industry[53]. The report notes the challenge of connecting employment to education in a sector which is rapidly changing because of technological innovations, which in turn constrains some of the opportunities for local workforces.

Impact on Local Sectors and Tourism

6.21 US studies have explored the expenditure impacts on sectors at a local level. A Cornell University (2011)[54] study found that a boost to local service sectors through increased expenditure could lead to increased prices and displacement of existing customers. The same study noted potential negative impacts through wage and labour substitution effects. This arises through the increase in the price of factors of production facing local businesses not in the oil and gas sector, as well as the loss of workers to operators in the oil and gas sector and its supply chain. This could lead to local businesses closing or choosing to leave the area, making the local economy more dependent on drilling activities and less diverse in the long run.

6.22 Another Cornell University study focused particularly on the effects of production activity within the Marcellus Shale on the tourism sector[55]. The study found that the activities associated with higher density development could, besides providing a boost to tourism in terms of expenditure, also have some detrimental impacts on local tourism sectors. The industrialisation associated with widespread drilling could do damage to the localities tourism 'brand' though changes in perceptions and visitor behaviour, especially where quality of the landscape and environment is an important part of the offer.

[51] Cornell University, 2011, Economic consequences of shale gas drilling.

[52] Marcellus Shale Education & Training Center, 2009, Marcellus Shale Workforce Needs Assessment.

[53] Bozick et al, 2017, Developing a Skilled Workforce for the Oil and Natural Gas Industry

[54] Cornell University, 2011, Economic consequences of shale gas drilling.

[55] Cornell University, 2011, Drilling in Marcellus Shale. Potential impacts on the tourism economy

Local public services

6.23 Unconventional gas exploration in an area could cause a strain on public services. The increased volume of traffic and trucks carrying heavy loads on local roads creates a greater need for policing through the need to control truck movement and weight limits[56]. The influx of workers can place a strain on local schools and hospitals, and increased costs for local governments.

6.24 A study of Sublette County[57], a rural county in Wyoming, shows that as a result of oil and gas industry development in the area, the permanent population had increased by 34% between 2000 and 2007. At the same time, the ambulance runs, medical visits, court cases, arrests and reported crimes had increased rapidly reflecting the impact from new and transient workers.

6.25 The IHS (2012) report estimates that in 2012 state and local tax receipts arising from unconventional oil and gas activity amounted to an estimated $31 billion (reflecting the use of state and county level taxes in the US). This represented 5% of US lower 48 States' total expenditures and 41% of the estimated 2012 budget gaps. However, (as noted above by Jacquet) while local governments may experience increases in revenue, there are also significant additional expenditures required to sustain the public infrastructure and services which experience a substantial and sustained increase in demand and other potential wider costs of unconventional gas and oil exploitation.

Other International Evidence

Europe

6.26 Poyry (2013)[58] conducted a study on the macroeconomic effects of European shale gas production. The study estimated that gas import dependency could fall from 89% in the scenario of no shale development to 78% in the middle shale production scenario, and 62% in the case of significant shale production scenario.

6.27 However, the report notes that the reality could be different due to the strong linkages between the European gas market with the US and Asia markets, as well as the potential development of shale gas in other parts of the world. The report reaches reasonably optimistic conclusions that shale gas development could result in lower gas and electricity wholesale prices. The projections in gas price reduction range from 6% to 14% depending on how rapidly the industry develops. Wholesale electricity prices could see a reduction of between 3% and 8%. The lower gas and electricity prices predicted in the shale gas development scenarios could also bring cost savings to industries within the EU. To some extent, businesses will pass lower costs onto consumers in the form of lower product prices, which would improve their competitive position in the markets, stimulating international demand for their goods.

6.28 More recently Janda and Kondratenko (2018)[59] undertook a study of the Economic Impacts of Shale Gas on EU Energy Security. The results of this study showed that shale production affects

[56] Cornell University, 2011, Drilling in Marcellus Shale. Potential impacts on the tourism economy

[57] Jacquet, 2009, Energy Boomtowns and Natural Gas: Implications for Marcellus Shale Local Governments and Rural Communities.

[58] Poyry, 2013, Macroeconomic effects of European shale gas production.

[59] Janda and Kondratenko, 2018, An Overview of Economic Impacts of Shale Gas on EU Energy Security.

the price negatively. The authors are of the view that European shale gas development is not able to affect the energy security of the EU on an international level.

UK Economic Impact Evidence

6.29 National onshore oil and gas economic studies have been undertaken by DECC, BEIS, Welsh Government, Scottish Government and UKOOG. All of the studies heavily draw on US economic impact evidence to the UK to help inform their assumptions. Also, local assessments have also been undertaken by developers with an interest in the potential plays in specific areas of the UK, including Cuadrilla and iGas. A number of the headline assumptions and impacts are summarised in the table at the end of the section.

6.30 As with the US literature, it is primarily focused on onshore unconventional resources as this has been seen as the main development opportunity for the UK. There is no recent research on the economic impact of exploitation of onshore conventional oil and gas resources

6.31 It should be noted that the economic impact estimates in this section have been criticised by various groups that are opposed to onshore oil and gas development. Friends of the Earth, for example, point to overstated employment impacts, selective use of findings in presenting more optimistic scenarios, the failure to distinguish between local employment and activities undertaken by a mobile workforce, and the failure to consider the range of potential negative impacts on other sectors (such as tourism and agriculture)[60].

National Shale Gas Studies

6.32 The Institute of Directors (2013) sought to assess the economic impact of onshore shale gas on the UK[61]. The report, was sponsored by Cuadrilla Resources Ltd. The study suggested that jobs created in the UK by unconventional gas could be 74,000 at peak and that spend could be up to £33 billion in supply chain activities from 2016 to 2032.

6.33 The study assumed that a single pad of 10 wells and 10 laterals could support 400 FTE jobs and a pad of 10 wells and 40 laterals could support just over 1,000 FTE jobs and that there is no leakage of expenditure out of the UK.

6.34 The study also estimated that for the widespread development scenario, UK gas import dependency could reduce to 46% and potentially as low as 27%. This was compared to the scenario of no or very limited shale gas by 2030, where import dependency would be 63%.

6.35 The report outlined the potential for the UK to secure reduced gas prices, as well as reduced prices for petrochemical feedstocks as a result of shale gas development. However, it pointed out that it is too early to say how significant these effects would be, this is attributed to the uncertainty around future gas prices.

6.36 In 2014, DECC undertook a Strategic Environmental Assessment[62] of potential oil and gas activity in the UK, covering all stages in the development lifecycle, under high and low activity scenarios for unconventional oil and gas[63]. The assessment estimated that for the high activity scenario

[60] Friends of the Earth, 2015, Making a better job of it.

[61] IoD, 2013, Getting shale gas working.

[62] DECC, 2013, Strategic Environmental Assessment for Further Onshore Oil and Gas Licensing

[63] The high activity scenario envisaged a total of between 1,440 and 2,880 wells being developed from 120 well pads with a

peak, 16,000 to 32,000 FTE jobs could be created by oil and gas development which represented an increase of between 3.5% and 7% in the level of employment supported by the UK oil and gas industry sector[64]. However, the potential for these jobs to directly benefit local communities in which sites are located would depend on the balance between skilled and unskilled construction and oil and gas posts required and the local labour market skills base.

6.37 The assessment identified that under the UKOOG (2013) Community Engagement Charter, benefits from shale gas exploration and production would be provided to host local communities and county/unitary authorities via an initial community contribution of £100,000 per well pad where fracturing takes place. Under the high activity scenario, total UK contributions could be between £3 and £12 million. During production, it was estimated that community benefits to the value of 1% of revenue from production could amount to a total of £2.4 million to £4.8 million per site (equivalent to between £0.3 billion and £0.6 billion across all sites) under the high activity scenario, assuming each well is productive for 20 years.

6.38 UKOOG commissioned Ernst & Young (2014)[65] to further examine the supply chain skills requirements and opportunities of a UK shale gas industry. Its estimates are based on the development scenario used in the Institute of Directors (IoD) report (2013), namely 4,000 wells drilled in the UK by 2032, requiring £33 bn of investment. The report estimates that:

- At peak 64,500 jobs would be created from upstream activities, 6,000 direct jobs, 40,000 indirect or supply chain jobs, and approximately 19,000 induced jobs (implying an indirect and induced employment multiplier of 9.8).
- UK oilfield service and manufacturing companies have an opportunity to develop the sector, as the development of shale gas requires specialist equipment and skills for hydraulic fracturing totalling £17 billion (out of the £33 billion).

6.39 The assessment of the UK water management industry showed that UK suppliers have the facilities to perform water treatment procedures and drilling waste management, although increased capacity would be required to treat waste volumes at peak. The need for waste storage and transportation infrastructure will depend on the proportion of treatment processes that can be conducted on-site, although there are no supply constraints anticipated. Furthermore, the UK has a well-developed waste transportation industry, with services for unconventional wells already established.

6.40 The report set out two specific recommendations, firstly defining a set of standard skills, qualifications and/or accreditations required by operators for staff to work on shale projects, and secondly defining a plan and investment case to develop required skills at pace.

6.41 In 2015 Welsh Government commissioned a study of the socio-economic impacts of unconventional gas development in Wales[66]. The study used the estimates of capital and operational spending for high, medium and low scenarios of coal bed methane and shale gas development.

- Under the low 'business as usual' scenario there is little additional economic impact.

peak number of 180 to 360 wells per annum being drilled and subject to hydraulic fracturing; the low scenario assumes a maximum of 360 wells from 30 pads.

[64] Oil and Gas UK, 2012, 2012 Economic Report.

[65] Ernst & Young, 2014, Getting ready for Shale Gas – Supply Chain Skills Requirements and Opportunities.

[66] Regeneris, Cardiff University and AMEC, 2015, Socio-economic Impact of Unconventional Gas in Wales.

- The annual GVA impact ranged from £1.4m to £3.1m under the medium scenario to £11.4m to £26.7m under the high scenario.
- The Annual FTE employment ranged from 34 to 72 jobs under the medium scenario to 270 to 630 jobs under the high scenario.

6.42 The study notes that at the outset production conditions in Wales would be very different from that in the US, and even if the primary production conditions were comparable, developers in Wales would face a different mix of planning constraints to those that US firms have typically faced. In this context the impacts should be viewed as illustrative and in the opinion of the authors. In addition, the study stated that the High activity scenario is on balance less likely to occur in this timescale given the wider uncertainties attendant on development in the sector.

6.43 Most recently, in 2016 KPMG was commissioned by the Scottish Government to undertake an assessment of the potential economic impacts of the development of unconventional oil & gas resources in Scotland[67].

6.44 The assessment covers a period from 2018 up to 2062 and the impacts are presented as cumulative impacts. The total GVA (cumulative to 2062) comes to £1.1 billion in the Medium scenario, with £0.1 billion in GVA generated directly added to £1.0 billion in indirect and induced effects (including CBM).

6.45 Peak year employment is used in the KPMG study to quantify the number of additional jobs that could be created by the unconventional oil & gas sector. The study assumes that a maximum of three pads would be built in any given year in the Medium scenario (4 in the High and 2 in the Low) and that once a pad is built, a given worker would then work on the next pad being built; resulting in one single job being maintained over a longer time rather than the creation of additional jobs for every pad built. In the medium scenario over 1,400 jobs would be created at the peak employment year.

6.46 Table 6.1 provides a summary of the findings of the five main national impacts assessments undertaken for the UK or devolved nations to date.

[67] KPMG, 2016, Economic Impact Assessment and scenario develop of unconventional oil and gas development in Scotland.

Table 6.1 Summary of Key Assumptions and Estimated Economic Impacts of UK National Shale Oil & Gas Studies

	IoD	EY	DECC SEA		Regeneris			KPMG		
Date Undertaken	2013	2014	2013		2015			2015		
Geographic Area	UK	UK	UK		Wales			Scotland		
Development Scenario	Central	Central	Low	High	Low	Central	High	Low	Central	High
Pads	100	100	30	120	3 CBM	4 CBM & 1 Shale	12 CBM & 8 shale	2 CBM & 10 shale	2 CBM & 20 shale	2 CBM & 31 shale
Wells per pad	10	10	NA	NA	4 to 6	4 to 6 CBM & 10 to 24 Shale	4 to 6 CBM & 10 to 24 Shale	15 CBM & 10 shale	15 CBM & 20 Shale	15 CBM & 20 shale
Laterals per well	4	4	6 -12 (per pad)	12-24 (per pad)	NA			-		
Period of drilling	16 years (2016-2032)	16 years (2016-2032)	9 years	12 years	3-4 years			-		
Production Lifetime	20 years	20 years	20 years		NA			12 years CBM & 15 years shale		
Scope of Coverage	Lifecycle	Upstream	NA		Lifecycle			lifecycle		
Total Development Expenditure (Lifetime)	£39bn	£33bn	£1.6bn-£3.2bn	£15.4bn - £26bn	£9.2 - £13.1m	£106.8 - £235.0m	£757.1 - £1,780.4m	£1.5bn	£4.4bn	£10.8bn
Total Development Expenditure (Lifetime) Per Pad	£388m	£330m	£54 m-£107m	£107m-£215m	£3.1 -4.4 m	£31.4 - 47m	£37.9 - 89m	£141m CBM & £110m shale	£141m CBM & £176m shale	£141m CBM & £299m shale
Total Development Expenditure (Lifetime) Per Well	£38.8m	£33m	NA		£0.74m	£1.6m	£2.88m	NA	NA	NA
Proportion of investment in geographic area	100%	100%	71%		32% - 38%			50% for CBM & 30%-60% for shale		
Laterals at peak (annually)	400	400	30-60	180-360	NA			NA		
Presented as peak or average annual employment?	Peak	Peak	Peak		Annual average / person years			Peak		
Annual Employment Per Lateral– Direct	-	15 (peak)	NA		NA			NA		
Annual Employment Per Lateral - Total	185 (peak)	161 (peak)	89 (peak)		1.1-1.6			NA		
Total Direct Employment (peak or average)	-	6,100 (peak)	NA		NA			430 (peak)	930 (peak)	1,280 (peak)
Total Employment including Indirect and Induced (peak or average)	74,000 (peak)	64,500 (peak)	2,600-5,300 (peak)	16,000-32,000 (peak)	2.6-3.7 (average annual) / 39-56	34-72 (average annual) / 510- 1,080	267-627 (average annual) / 4,010 - 9,410	470 (peak)	1,400 (peak)	3,100 (peak)

Source: DECC, 2013, Strategic Environmental Assessment for Further Onshore Oil and Gas Licensing; Ernst & Young, 2014, Getting ready for Shale Gas – Supply Chain Skills Requirements and Opportunities; IoD, 2013, Getting shale gas working; Regeneris Consulting, Cardiff University and AMEC, 2015, Socio-economic Impact of Unconventional Gas in Wales; KPMG, 2016, Economic Impact Assessment and scenario develop of unconventional oil and gas development in Scotland.

Regional and Local Impact Assessments

6.47 There is limited recent regional and local economic impact assessments of unconventional oil and gas in the UK, although a number of studies were undertaken in the early 2010s. The impacts predicted by these studies have not been reached due to the restrictions on fracking in the UK over the last 4-5 years.

6.48 A study of the potential economic impacts of the future exploration and exploitation of shale gas in the Ocean Gateway area of the North West of England was commissioned by IGas and Peel Developments in 2014[68]. The development scenario consisted of a total of 300 vertical wells and 1,200 laterals, with overall investment totalling £9.8 billion - similar to the intensity of scenarios used in the IoD and Ernst and Young assessments.

6.49 Peak level employment was estimated to be around 15,500 FTE jobs in the UK, of which 3,500 (23%) were estimated to be in the Ocean Gateway area. The UK employment is based on an assumption that all supply chain activity is located in the UK, which appears to be predicated on the UK developing a largescale unconventional oil and gas sector. The extent to which the development activity supports local employment was shaped by the following assumptions:

- Local residents have time to acquire the relevant skills, whilst others relocate permanently to the area. It was assumed that 40% of direct jobs are local.
- A third (35%) of Tier 1 suppliers would locate operations in the area, with subsequent tier operators co-locating some of their activity (up to 15%) in Ocean Gateway.

6.50 In 2015 AMION Consulting undertook a study for Peel into the economic impacts of a Bowland Shale supply hub[69]. The study found that a co-located supply chain could more than double the supply chain spend retained in the Bowland Shale area and create over 13,000 local peak year jobs – 7,800 more than without the creation of a supply hub. The study assumed there would be 100 well pads and 1,000/2,000 wells. This would result in a peak annual spend of £2.6 billion and a cumulative spend (to 2048) of £30.6 billion. The employment impact would reach a peak year impact of 13,000 assuming the development of a local integrated supply hub.

Summary

6.51 The US 'shale boom' has resulted in a significant amount of economic impact evidence related to the development of unconventional oil and gas. The US evidence points to the significant economic impacts resulting from the development of onshore oil and gas. This is mainly due to the specific circumstances under which the US has developed its oil and gas industry. There is very little geographical leakage of economic impacts out of the US due to the size and level of self-containment of economic activity in the US economy and the strengths of its oil and gas and related supply chains. In addition, the US has a relatively strong and large employment and skills base to draw upon and has the critical mass required to further develop its supply chains and skills base.

6.52 The sustainability of some of these economic impacts has been questioned by some commentators as a result of the pandemic and associated economic downturn and its impact on global oil and gas prices. This has led to wells being mothballed and others abandoned as producers have failed.

[68] AMION Consulting. 2014. Potential Economic Impacts of Shale Gas in the Ocean Gateway.

[69] AMOIN Consulting, 2015. Creating a supply hub for the Bowland Shale.

6.53 Looking at the wider economic impact evidence the US evidence provides insights into workforce requirements, training education and some of the opportunities that may be available to local people and the challenge to increase local benefits. In addition, the evidence also provides insights on the potentially negative economic impacts on tourism and other sectors and local public services, although an important message is that this often depends heavily on the circumstances and nature of the locations in which development occurs.

6.54 In comparison, the circumstances in which the UK would develop its unconventional oil and gas sector are very different. The moratoria in GB and RoI on unconventional activity are a major constraint on the development of the sector and the associated supply chains and skills base. Achieving the critical mass needed to attain the high levels of economic impacts reported by UK and regional impact studies is highly unlikely in the current climate.

6.55 Due to the significant differences between the US and UK, more recent UK studies such as those focused on Wales and Scotland have been more conservative in the scale of economic impacts which could be achieved across different development scenarios.

6.56 Northern Ireland lacks an indigenous oil and gas sector, although it has a sizeable geosciences sector and a range of sectors which could form part of the supply chain if future oil and gas development were to occur. Nevertheless, as outlined later in the report, the nature of the Northern Ireland economy and its infrastructure would limit the scope to secure economic benefits from future onshore oil and gas development.

7. Economic Impact Assessment

Introduction

7.1 This section sets out the estimation of the economic impacts which are expected to occur under each of the development scenarios. This focuses on the direct, indirect and induced impacts within Northern Ireland, measured through indicators such as Gross Value Added (GVA) and employment creation.

7.2 It also considers the wider potential economic benefits or disbenefits which might arise if development was to occur. This includes the indirect effects on sectors which could use the oil and gas as inputs and sectors which might be affected by loss of land or changes in their amenity (e.g. tourism, agriculture). It also considers impacts on energy security, energy prices and trade balances.

7.3 Whilst production would generate royalty income, this would flow to the UK Exchequer rather than being retained within Northern Ireland (apart from compensation to landowners who can prove their holding of mineral rights prior to 1964 Act). The royalties have not therefore been estimated as part of this assessment.

Assessment Approach

7.4 This section outlines the approach to assessing the economic impacts resulting from onshore oil and gas development in Northern Ireland. The assessment of economic impact focuses on the GVA and employment impacts of the potential development scenarios. For the key quantitative measures of economic impact (employment and GVA) Hatch developed an economic impact model to estimate the direct, indirect and induced employment impacts supported by exploration, development, production and decommissioning phases.

7.5 The no development scenario assumes that no exploration or commercial exploitation takes place in Northern Ireland over next three decades. The assessment briefly covers the expected economic impacts under this scenario where appropriate.

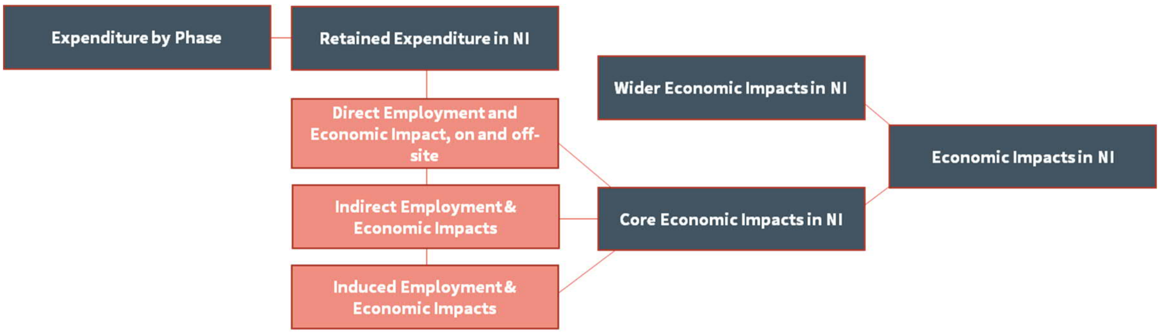
Input Output Tables

7.6 Input Output tables can be used to model the direct, indirect and induced impacts of expenditure within the Northern Ireland economy. The modelling exercise drew on Hatch's in-house Input Output tables which quantitatively represent the interdependencies between sectors. Hatch frequently use bespoke in-house economic tables and we have applied this to a wide range of energy contexts including oil & gas development and on and offshore wind projects.

7.7 A key aspect of the economic modelling was to map the expenditure categories for each phase against the sector categories in the input output table on a best fit basis. For example, expenditure which is heavily reliant on the construction sector would be matched to the construction sector within the input output model. Each sector within the input output table has different economic multipliers which vary based on the variation on interdependencies across sectors.

Direct (on & offsite), Indirect and Induced Economic Impacts

Figure 7.1 Economic Assessment Approach



Source: Hatch, 2021

7.8 Direct impact captures the economic activity that is supported directly through the lifetime and decommissioning of onshore oil and gas development. This covers direct staff employed on- and off-site and all first-tier supply chain expenditure relating to the exploration, development, production and decommissioning of the oil and gas facilities.

7.9 Indirect impacts measure the supply chain impact of the additional output generated by companies in the supply chain supporting the tier one suppliers. The additional economic activity in these companies is passed down through their supply chains and generates additional, indirect benefits for many other companies across the Northern Ireland economy.

7.10 Induced impacts capture the knock-on benefits that additional employment supported directly and indirectly has in the Northern Ireland economy as salaries - earned by those employed in additional jobs - are spent on goods and services elsewhere in the economy.

7.11 To derive the total economic benefits, direct, indirect and induced employment and economic impacts are added together.

Presenting the Impacts and Dealing with Uncertainties

7.12 The economic impacts are presented on the basis of the total impacts, per annum and by development phases for each development scenario. It should be noted that other impact studies present the impacts on a peak impact basis. Hatch do not model peak impact in the same way as other studies owing to the uncertainty associated with the precise timing of investment and activity within phases, however we take the average employment impacts over different phases and aggregate these where phases overlap to provide insight into the profile of employment over the course of the thirty year assessment period.

7.13 The GVA impacts are presented in 2021 prices and are not discounted. It removes the effects of inflation and presents impacts in a common currency without adjusting for social time preference (which is more relevant for investment appraisal, especially where competing options are being considered which have different cost/benefit profiles).

7.14 The impacts for the high, medium and low oil and gas development scenarios are presented as ranges to allow for the uncertainties associated with the potential retention of expenditure within Northern Ireland (compared to the potential for it to leak out of the region) and the intensity of drilling at the exploration and production sites.

Estimating the Core Economic Impacts

Sourcing of Inputs and Retained Expenditure in NI

7.15 The retention of expenditure associated with development, operation and decommissioning of the onshore oil and gas industry in Northern Ireland directly impacts on the level of economic impact Northern Ireland will capture as a result of future onshore oil and gas development.

7.16 This assessment has drawn on a variety of evidence to reach assumptions on the level of expenditure which could be retained within the Northern Ireland economy. To reach these assumptions which are backed by a sound evidence base, the following evidence has been assessed:

- Information on the assumptions for the level of retained expenditure in other UK oil and gas economic impact studies
- Information available on businesses currently within Northern Ireland who are operating in the UK and global oil and gas supply chains[70], as well as analysis of the capacity and capability of sectors in Northern Ireland which could form part of the supply chains if onshore oil and gas development were to occur
- Evidence gathered from stakeholder engagement including with the oil and gas industry and economic development agencies.

7.17 Several UK oil and gas economic impact studies made assumptions on the level of retained expenditure within their impact areas. The most useful economic impact studies Hatch assessed are shown in Table 7.1 below.

Table 7.1 Evidence from UK Onshore Oil and Gas Economic Impact Studies

Economic Impact Study	Level of Retained Spend
2015, Wales Economic Impact Study by Regeneris	32%-38% retained spend in Wales (low to high scenarios)
2015, Scotland Study by KPMG	30%-60% retained spend in Scotland (low to high scenarios)
2013, UK SEA Study by DECC	71% retained spend in the UK

Hatch desk-based research, 2021.

7.18 Table 7.2 presents the sourcing assumptions used in this assessment for each of the detailed expenditure category level and the rationale underpinning the assumptions. This has been informed by similar assessments for other regions of the UK, such as the assessment of unconventional oil and gas in Scotland, as well as an analysis of the potential of NI's business base to supply these categories of goods and services.

[70] Research was conducted by Invest Northern Ireland on the capabilities of the oil and gas supply chain within Northern Ireland. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/237643/ni_supply_chain_directory.pdf

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Table 7.2 Detailed Cost and Sourcing Assumptions

Cost category		% of Expenditure Retained in Northern Ireland	Information used to inform retained expenditure assumption
Main Category	Subcategory		
Planning and Licensing		60%-80%	Expected to be mostly sourced within Northern Ireland, but some work may be outsourced by local offices of international practices to the rest of the UK (hence reduced to allow for leakage of wages and profits). Larger companies operating in NI might expand their existing offices in response to opportunities under high scenario.
Exploration		20%-30%	Northern Ireland lacks much of the specialist equipment and expertise required. However, some expenditure will be retained associated in supporting activities.
Pad Development costs		60%-75%	The strong construction and civil engineering sector in NI will help to retain a high proportion of expenditure.
Drilling and Completion	Security services	100%	Site security services are widely available in NI and it is expected that all this expenditure will be retained within Northern Ireland.
	Steel casing	50%-65%	NI has a number of general and specialist metal fabricators, including metal piping. The potential to retain expenditure is therefore considered moderate.
	Rig hire	0%	Rigs are likely to be sourced from outside of Northern Ireland, either from RoI or GB (or further afield if development activity in NI and GB were to create considerable demand compared to limited rig supply).
	Ancillary Equipment and service	10%-15%	Industry consultations suggest NI has limited existing capacity in the supply of ancillary equipment and services for the oil and gas sector. Retention of expenditure is assumed to be low.
	Cementing services	50%-65%	NI has strong capabilities within the manufacture of cements, including some specialist products. Retention of expenditure is assumed to be medium.
	Directional drilling service	0%	This is specialist equipment which is highly likely to be sourced from outside of Northern Ireland, possibly from the US.
	Drilling fluids and fluids engineering	30%-45%	There are reasonable opportunities to source locally.
	Drill rig fuel	100%	The requirement for fuels is standard. It is therefore expected that all of the expenditure would be retained within NI.
Hydraulic Fracturing	Equipment	0%	Specialist equipment, with specialist mobile teams required. This is in limited supply in Europe. The moratorium in development in GB will limit any expected growth in supply that was expected under an active development scenario. Consultation with Invest NI indicated Northern Ireland's oil and gas supply chain is very limited, although some activity around making valves for the oil and gas activity out of Aberdeen (although this work is drying up).
	Proppants	40%-55%	Potentially good supply of suitable sands for fracking of wells. Retention of expenditure is assumed to be medium.
	Other[71]	10%-15%	These categories cover a wide range of products and services, some fairly specialist, and the associated level of expenditure is modest. Retention of expenditure is assumed to be low.
	Mobilisation / demobilisation	10%-15%	
	Miscellaneous[72]	10%-15%	
Wastewater Disposal	Wastewater management	70%-90%	Northern Ireland has a relative strength in the water supply, waste treatment and management industry. The water industry is closely related to supporting the agri-food sector (which is a strong sector within Northern Ireland). Retention of expenditure is assumed to be high.
	Drilling waste management	70%-90%	
	Waste transportation	70%-90%	NI has a relative strength in the waste transportation sector. Retention of expenditure is assumed to be high.
	Water and storage transportation	70%-90%	NI has a strength in the water and storage transportation sectors.
Operational Expenditure		50%-70%	Many of the services and skills required would be sourced within NI. More specialist skills, equipment and spares could be sourced from outside Northern Ireland. Location of operators bases in NI would help to retain expenditure.
Decommissioning and Aftercare		50%-70%	As with construction, there are good opportunities to retain expenditure given construction and specialist remediation and monitoring services.

Hatch Calculations, 2021

7.19 Table 7.3 shows the estimated total cost per well and the breakdown by the categories of expenditure (based on both high and low intensity drilling). The high and low assumptions of the percentage retained expenditure in NI for each category (shown in Table 7.2) is then applied to these costs to derive the value of retained expenditure in NI. This provides estimates of the retained expenditure by expenditure category per well for high and low drilling intensity assumptions in NI. The retained expenditure per well in NI is estimated to be between £6.3m (low sourcing/low drilling intensity) to £9.4m (high sourcing-high intensity drilling) per well.

[71] 'Other' includes expenditure on chemicals e.g. polymers or surfactants, or acid.

[72] 'Miscellaneous' covers costs associated with general wear and tear of equipment and spares.

Table 7.3 Detailed Cost and Sourcing Assumptions

Cost category		Assumption		Retained Expenditure per Well (£m)
Main Category	Subcategory	Total Cost Per Well (£m) - range is based on low and high intensity drilling	% of Expenditure Retained in Northern Ireland	
Planning and Licensing		0.09	60%-80%	0.05-0.07
Exploration		0.60	20%-30%	0.12-0.18
Pad Development costs		2.06	60%-75%	1.24-1.55
Drilling and Completion	Security	1	100%	1
	Steel casing	0.97 - £1.39	50%-65%	0.49-0.90
	Rig hire	0.92 - £1.31	0%	0
	Ancillary Equipment and service	0.51 - £0.73	10%-15%	0.05-0.11
	Cementing services	0.35 - £0.50	50%-65%	0.18-0.33
	Directional drilling service	0.32 -£0.45	0%	0
	Drilling fluids and fluids engineering	0.24 - £0.34	30%-45%	0.07-0.15
	Drill rig fuel	0.19 - £0.28	100%	0.19-0.28
Hydraulic Fracturing	Equipment	6.24 - £8.32	0%	0
	Proppants	0.74 - £0.99	40%-55%	0.30-0.54
	Other	0.27 - £0.36	10%-15%	0.03—0.05
	Mobilisation / demobilisation	0.17 - £0.22	10%-15%	0.02-0.03
	Miscellaneous	0.08 - £0.10	10%-15%	0.01-0.02
Wastewater Disposal	Wastewater management	0.36	70%-90%	0.25-0.32
	Drilling waste management	0.33	70%-90%	0.23-0.30
	Waste transportation	0.18	70%-90%	0.13-0.17
	Water and storage transportation	0.13	70%-90%	0.09-0.12
Operational Expenditure		3.00 - £4.00	50%-70%	1.50-2.80
Decommissioning and Aftercare		0.75	50%-70%	0.38-0.53
Total		19.50 - 24.50		6.31-9.44

Hatch Calculations, 2021,

7.20 In addition, Table 7.4 presents a higher level expenditure breakdown for each expenditure category. It is important to note that the level of sourcing varies by a small amount from low drilling to high drilling intensity. This is due to the differing cost profile at different levels of drilling intensity. When drilling intensity is higher there is a greater proportion of expenditure associated with activities which have lower retention of expenditure in NI (and vice versa for low drilling intensity).

Table 7.4 Costs, Sourcing and Retained Expenditure Levels Per Well

Total cost per well £m		£19.50-£24.50 (range defined by high and low intensity drilling)	
Total Expenditure Retained in NI £m (per well)		£9.44 (high Sourcing–high intensity drilling	£6.31 (low sourcing-low intensity drilling)
Expenditure Retained in NI £m (per well) across broad expenditure categories	Development & Exploration	£1.80	£1.41
	Drilling	£2.24-£2.77	£1.98-£2.40
	Fracturing	£0.49-£0.65	£0.35-£0.46
	Waste Management	£0.90	£0.70
	Operations	£2.10-£2.80	£1.50-£2.00

	Decommissioning and aftercare	£0.53	£0.38

Hatch Calculations, 2021.

7.21 Table 7.5 shows the potential total lifetime retained expenditure across the development scenarios. The expenditure ranges presented account for the high to low sourcing and drilling intensities. The estimated retained expenditure in NI is therefore:

- low scenario - £63.1 million to £94.4 million (covering both the development of conventional and unconventional oil and gas)
- medium scenario - £113.6 million to £169.9 million
- high scenario - £214.6 to £320.9 million.

7.22 There is the potential for the supply side of the economy in NI to adapt to the opportunities presented under the high scenario, as local suppliers enhance their capacity and capacity to supply goods, services and skills. The prospect of being closer to a developing market may also attract elements of the oil and gas supply chain to Northern Ireland. However, the assessment assumes that the scale of the opportunity is not sufficient, even under the high scenario, for an effect of this type to be significant (and bearing in mind the moratoria in the rest of the UK and the Republic of Ireland).

7.23 It is assumed that the total expenditure associated with the no development is zero.

Table 7.5 Retained Expenditure in NI by Development Scenario (£ millions)

Development Phase	Low		Medium		High	
	Conventional	Unconv'al	Conventional	Unconv'al	Conventional	Unconv'al
Number of Wells	4	6	6	12	10	24
Lateral Intensity	8-16	12-24	12-24	24-48	24-48	48-96
Development & Exploration	£5.65-£7.20	£8.47-£10.80	£8.47-£10.80	£16.94-£21.59	£14.12-£17.99	£33.89-£43.18
Drilling	£7.91-£11.07	£11.87-£16.61	£11.87-£16.61	£23.73-£33.21	£19.78-£27.68	£47.46-£66.43
Fracturing	£1.39-£2.59	£2.09-£3.88	£2.09-£3.88	£4.18-£7.76	£3.58-£6.47	£8.36-£15.53
Waste Management	£2.80-£3.60-	£4.20-£5.40	£4.20-£5.40	£8.40-£10.80	£7.00-£9.00	£16.80-£21.60
Operations	£6.00-£11.20	£9.00-£16.80	£9.00-£16.80	£18.00-£33.60	£15.00-£28.00	£36.00-£67.20
Decommissioning and aftercare	£1.50-£2.10	£2.25-£3.15	£2.25-£3.15	£4.50-£6.30	£3.75-£5.25	£9.00-£12.60
Total	£25.25-£37.76	£37.88-£56.63	£37.88-£56.63	£75.75 - £113.27	£63.13-£94.39	£151.50-£226.53

Hatch Calculations, 2021. Numbers may not sum due to rounding. The ranges presented account for the ranges of high to low sourcing and drilling intensities. The lower estimates represent a scenario with low drilling intensity and sourcing and the upper estimates represent a scenario with high drilling intensity and sourcing.

GVA and Employment Impact Estimates

7.24 The following section presents the assessment of the economic impacts in NI which are estimated to occur under low, medium and high development scenarios. The assessment presents total GVA and employment impacts over the period 2021 to 2050, as well as the average annual impacts. The estimates are also presented by development phase (with the annual impacts averaged over the duration that in which the activities are most likely to occur) and conventional and unconventional resources in turn. The estimates also distinguish between direct, indirect and induced economic effects (activity supported as the industries involved purchases goods and services in Northern Ireland, and associated effects linked to the spending of wage income). The results presented in this section are presented as ranges to account for uncertainties over the level of sourcing and drilling intensity.

Impact by Development Phases

7.25 The development periods have been used as the basis for estimating the annual average economic impacts associated with the scenarios (e.g., activity under the initial surveying, site selection and planning phase could occur between 2021 and 2032, a period of 12 years; in the case of the drilling phase, the main drilling activity could take place between 2024 and 2035, although it might be prolonged up to around 2046 through the re-fracking of wells).

GVA Impacts by Phase

7.26 The total lifetime GVA Impacts resulting from low, medium and high development scenarios are presented in Table 7.6 below. Of the four phases site preparation, drilling and testing has the largest direct GVA and total GVA impacts, accounting for over half of the total GVA impact. This is due to the high level of expenditure (total retained expenditure is highest in this phase) associated with this development phase. The overall scale of the estimated GVA impacts in NI varies between £67 and £99 million under the low scenario to between £229 and £338 million under the high scenario over the period 2021 to 2050.

Table 7.6 GVA impacts in NI by phase of development and low, medium and high development scenarios

Development Scenario	Phase of development	GVA Impacts (£ millions) within Northern Ireland			
		Direct	Indirect	Induced	Total
Low	Surveying, site selection and planning	6-8	5-7	4-5	15-19
	Site preparation, drilling and testing	17-23	6-9	9-12	32-44
	Production	6-11	6-11	4-8	16-30
	Decommissioning and restoration	1-2	1-2	1	4-6
	Total	30-44	19-29	18-26	67-99
Medium	Surveying, site selection and planning	11-14-	9-12	7-9	27-34
	Site preparation, drilling and testing	31-42	11-15	16-22	58-79
	Production	11-20	11-20	8-14	29-54
	Decommissioning and restoration	3-4	3-4	2-3	7-10
	Total	55-80	33-48	33-48	121-179
High	Surveying, site selection and planning	20-26	18-23	13-16	51-65
	Site preparation, drilling and testing	58-80	20-29	31-42	109-151
	Production	20-38	20-38	15-27	55-103
	Decommissioning and restoration	5-7	5-7	4-5	14-19
	Total	104-150	62-97	62-90	229-338

Hatch Calculations. The values presented in this table are rounded to the nearest £ million. Numbers may not sum due to rounding. The lower bound represents a development scenario with low drilling intensity and sourcing assumptions. The upper bound represents a development scenario with high drilling intensity and sourcing assumptions.

7.27 By taking the lifetime GVA impact for each phase and annualising this based on the estimated duration over which the phase will occur it is possible to provide an indication of the average annual impacts of each development phase. Table 7.7 contains the annual GVA impact results. Surveying, site selection and planning has the largest direct GVA and total GVA impacts per annum. This is largely due to the relatively shorter duration over which this activity occurs and the higher proportion of retained expenditure associated with this activity.

7.28 The analysis highlights that whilst the GVA impact are sizeable in aggregate over the thirty year period of the impacts assessment, on an average annual basis it is much more modest. The main factors which influence this are the degree of expenditure leakage out of the region (much of this linked to the requirement for goods and services which cannot be sourced locally), and the uneven manner in which the associated activity is spread over a long time period. Average annual GVA impacts in NI by phase of development and low, medium and high development scenarios.

Table 7.7 Average GVA impacts per annum in NI by phase of development and low, medium and high development scenarios

Development Scenario	Phase of development	GVA Impacts Per Annum (£ millions) within Northern Ireland			
		Direct	Indirect	Induced	Total
Low	Surveying, site selection and planning	0.5-0.6	0.4-0.6	0.3-0.4	1.3-1.6
	Site preparation, drilling and testing	0.7-1.0	0.3-0.4	0.4-0.5	1.4-1.9
	Production	0.2-0.4	0.2-0.4	0.2-0.3	0.6-1.2
	Decommissioning and restoration	0.1	0.1	0.1	0.3-0.4
	Average across the development lifecycle	1.0-1.5	0.6-1.0	0.6-0.9	2.2-3.3
Medium	Surveying, site selection and planning	0.9-1.2	0.8-1.0	0.6-0.7	2.3-2.9
	Site preparation, drilling and testing	1.3-1.8	0.5-0.7	0.7-1.0	2.5-3.5
	Production	0.4-0.8	0.4-0.8	0.3-0.6	1.2-2.2
	Decommissioning and restoration	0.2	0.2-0.3	0.1-0.2	0.5-0.7
	Average across the development lifecycle	1.8-2.7	1.1-1.7	1.1-1.6	4.0-6.0
High	Surveying, site selection and planning	1.7-2.2	1.5-1.9	1.1-1.4	4.3-5.4
	Site preparation, drilling and testing	2.5-3.5	0.9-1.3	1.3-1.8	4.7-6.5
	Production	0.8-1.5	0.8-1.5	0.6-1.1	2.2-4.1
	Decommissioning and restoration	0.3-0.5	0.3-0.5	0.2-0.3	0.9-1.3
	Average across the development lifecycle	3.5-5.0	2.1-3.2	2.1-3.0	7.6-11.3

Hatch Calculations. The values presented in this table are rounded to the nearest £100,000. Numbers may not sum due to rounding. The lower bound represents a development scenario with low drilling intensity and sourcing assumptions. The upper bound represents a development scenario with high drilling intensity and sourcing assumptions.

Employment Impacts

7.29 The employment impacts resulting from the low, medium and high development scenarios are presented in Table 7.8 below. As with the GVA impacts, of the four phases site preparation, drilling and testing has the largest direct employment and total employment impacts, accounting for over half of the total employment impact over the development lifecycle. This is due to the higher level of expenditure (which drives jobs creation) associated with this activity. The total person years of employment which is estimated to be supported in NI ranges from 980 and 1,380 under the low scenario to between 3,350 and 4,680 in the high scenario.

Table 7.8 Total person years employment (FTE) impacts In NI by phase of development and low, medium and high development scenarios

Development Scenario	Phase of development	Employment Impacts (Person Years) within Northern Ireland			
		Direct	Indirect	Induced	Total
Low	Surveying, site selection and planning	60-70	70-90	60-70	180-230
	Site preparation, drilling and testing	320-380	90-130	130-180	540-690
	Production	60-120	80-150	60-120	210-380
	Decommissioning and restoration	20	20-30	20	50-70
	Total	460-600	260-390	270-390	980-1,380
Medium	Surveying, site selection and planning	100-130	120-160	100-130	330-420
	Site preparation, drilling and testing	580-690	160-230	240-330	980-1,240
	Production	120-220	140-260	110-210	370-690
	Decommissioning and restoration	30-40	30-50	30-40	90-130
	Total	830-1,080	460-700	490-710	1,770-2,480
High	Surveying, site selection and planning	200-250	240-300	190-240	620-780
	Site preparation, drilling and testing	1,090-1,300	300-430	460-610	1,850-2,340
	Production	220-410	270-500	220-400	700-1,310
	Decommissioning and restoration	50-80	50-90	50-80	170-240
	Total	1,560-2,030	870-1,310	920-1,330	3,350-4,680

Hatch Calculations. The values presented in this table are rounded to the nearest 10 jobs. Numbers may not sum due to rounding. The lower bound represents a development scenario with low drilling intensity and sourcing assumptions. The upper bound represents a development scenario with high drilling intensity and sourcing assumptions.

7.30 As with GVA impacts, by taking the total person years of employment for each phase and annualising this based on the estimated duration over which the phase will occur it is possible to estimate the average annual impacts of each development phase. Table 7.9 contains the average annual employment impact results. Surveying, site selection and planning has the largest direct and total employment impact per annum, as with the GVA impact this is largely due to the shorter duration over which this activity occurs and the high proportion of retained expenditure associated with this activity.

7.31 It is clear that the level of annual average employment supported in Northern over the thirty year development period is fairly modest under all scenarios. It ranges from between 35-45 person years of employment per year under the low scenario to between 110-155 under the high scenario. To put these employment figures into context a recent report by the DfE NI (2020)[73] stated that in 2017, around 3,860 employee jobs were supported in the energy sector in Northern Ireland. Which was equivalent to 0.5% of all employee jobs in NI in 2017. In addition, the report stated in the three-year period 2016-2018 in Northern Ireland, an estimated annual average of around £1 billion in turnover and 5,900 full time equivalent (FTE) jobs were generated directly

[73] DfE Northern Ireland, 2020, Energy in Northern Ireland 2020.

by businesses active in the low carbon and renewable energy economy in each of the years 2016 to 2018.

Table 7.9 Average Employment (FTE) impacts per annum in NI by phase of development and low, medium and high development scenarios

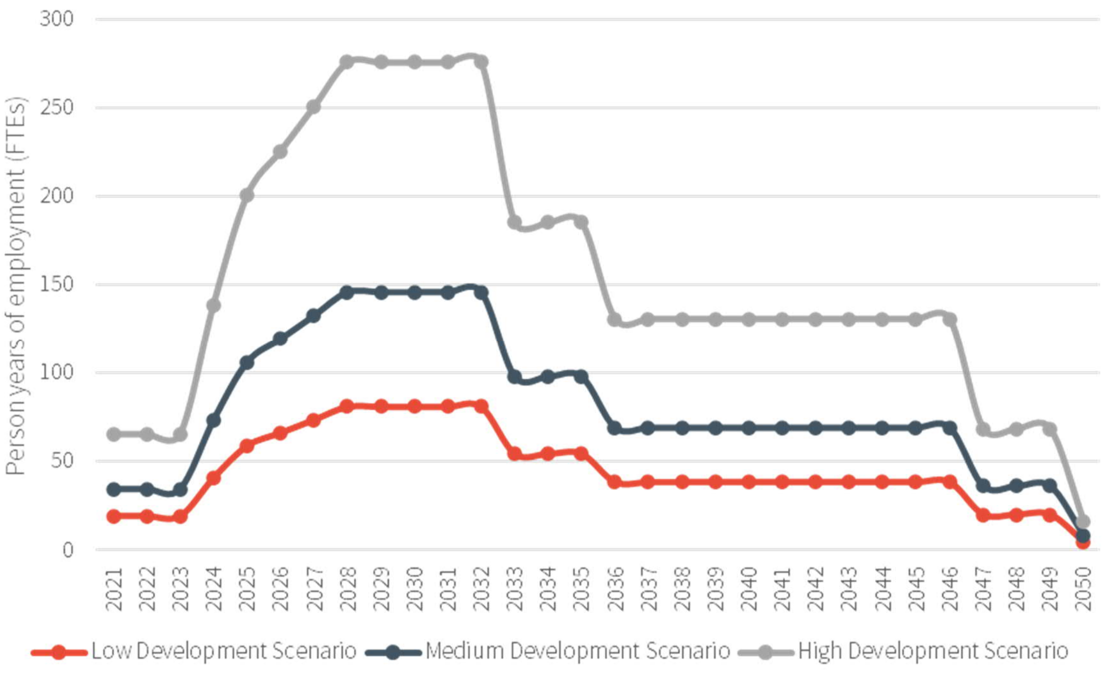
Development Scenario	Phase of development	Employment Impacts (Person Years) within Northern Ireland			
		Direct	Indirect	Induced	Total
Low	Surveying, site selection and planning	5	5	5	15-20
	Site preparation, drilling and testing	15	5	5-10	25-30
	Production	5	5	5	10-15
	Decommissioning and restoration	1	1-2	1	3-5
	Average across the development lifecycle	15-20	10-15	10-15	35-45
Medium	Surveying, site selection and planning	10	10-15	10	30-35
	Site preparation, drilling and testing	25-30	5-10	10-15	45-55
	Production	5-10	5-10	5-10	15-30
	Decommissioning and restoration	2-3	2-3	2-3	6-9
	Average across the development lifecycle	30-35	15-25	15-25	60-85
High	Surveying, site selection and planning	15-20	20-25	15-20	50-65
	Site preparation, drilling and testing	50-55	15-20	20-25	80-100
	Production	10-15	10-20	10-25	30-50
	Decommissioning and restoration	4-5	4-6	4-5	12-16
	Average across the development lifecycle	50-70	30-45	30-45	110-155

Hatch Calculations. The values presented in this table are rounded to the nearest 5 jobs and values in the decommissioning and restoration phase are rounded to the nearest 1 job (due to the smaller economic impacts associated with this phase). Numbers may not sum due to rounding. The lower bound represents a development scenario with low drilling intensity and sourcing assumptions. The upper bound represents a development scenario with high drilling intensity and sourcing assumptions.

7.32 Figure 7.1 indicates how employment that is estimated to be supported in each of the development scenarios would be spread across the assessment period. The profile is estimated on the basis of the expected expenditure profiles for each scenario and timing of the associated development phases. It is clear that the additional jobs would be concentrated over the first fifteen years, thereafter reducing by around a half as wells moved into their steady state production phase.

7.33 Given the delays which can occur during licensing, exploration and planning, there is the potential for the timing of employment creation associated with the earlier phases of development to be delayed. In addition, as the employment levels have been averaged across the respective phases, there is the potential for the peak employment levels to be higher than the maximum average show in the chart (although this will be mirrored in lower employment at other times over the thirty years).

Figure 7.2 Estimated Total Employment Impact Timeline (under high drilling intensity and sourcing assumptions)



Source: Hatch Calculations, 2021. The employment estimates are based on the aggregated average person years employment impact for each phase of development per annum across the development lifecycle. Please note that employment impacts during the Site Preparation, drilling and testing phase were allocated on the basis that 70% of the total expenditure to the first 12 years of the phase and the remaining 20% of expenditure would be spread over the remaining 11 years.

Impacts by Conventional and Unconventional Oil and Gas Development

7.34 The analysis also presents economic impacts by the extraction of unconventional and conventional resources. For both GVA and employment impacts, the scale of total and annual average impacts are larger for the unconventional activity and proportionately greater under the high compared to the low development scenario. This is due to the assumption that there is greater opportunity to up scale the unconventional exploration and production activity given the geology of Northern Ireland.

Table 7.10 Total GVA impacts in NI by type of development activity and low, medium and high development scenarios

Development Scenario	Type of development	GVA Impacts (£ millions) within Northern Ireland			
		Direct	Indirect	Induced	Total
Low	Unconventional	18-27	11-16	11-16	40-60
	Conventional	12-18	7-11	7-11	27-40
	Total	30-44	19-29	18-26	67-99
Medium	Unconventional	37-53	22-32	22-32	81-119
	Conventional	18-27	11-16	11-16	40-60
	Total	55-80	33-48	33-48	121-179
High	Unconventional	73-106	44-64	44-64	161-238
	Conventional	30-44	18-26	18-26	67-99
	Total	104-150	62-90	62-90	229-338

Hatch Calculations. The values presented in this table are rounded to the nearest £ million. Numbers may not sum due to rounding. The lower bound represents a development scenario with low drilling intensity and sourcing assumptions. The upper bound represents a development scenario with high drilling intensity and sourcing assumptions.

Table 7.11 Average annualised GVA impacts in NI by type of development activity and low, medium and high development scenarios

Development Scenario	Type of development	GVA Impacts Per Annum (£ millions) within Northern Ireland			
		Direct	Indirect	Induced	Total
Low	Unconventional	0.6-0.9	0.4-0.6	0.4-0.5	1.3-2.0
	Conventional	0.4-0.6	0.2-0.4	0.2-0.4	0.9-1.3
	Total	1.0-1.5	0.6-1.0	0.6-0.9	2.2-3.3
Medium	Unconventional	1.2-1.8	0.7-1.1	0.7-1.1	2.7-4.0
	Conventional	0.6-0.9	0.4-0.6	0.4-0.5	1.3-2.0
	Total	1.8-2.7	1.1-1.7	1.1-1.6	4.0-6.0
High	Unconventional	2.4-3.5	1.5-2.3	1.5-2.1	5.4-7.9
	Conventional	1.0-1.5	0.6-1.0	0.6-0.9	2.2-3.3
	Total	3.5-5.0	2.1-3.2	2.1-3.0	7.6-11.3

Hatch Calculations. The values presented in this table are rounded to the nearest £100,000. Numbers may not sum due to rounding. The lower bound represents a development scenario with low drilling intensity and sourcing assumptions. The upper bound represents a development scenario with high drilling intensity and sourcing assumptions.

Table 7.12 Total person years employment (FTE) in NI by type of development activity and low, medium and high development scenarios

Development Scenario	Type of development	Employment Impacts (Person Years) within Northern Ireland			
		Direct	Indirect	Induced	Total
Low	Unconventional	280-360	150-230	160-240	590-830
	Conventional	180-240	100-150	110-160	390-550
	Total	460-600	260-390	270-390	980-1,380
Medium	Unconventional	550-720	310-460	320-470	1,180-1,650
	Conventional	280-360	150-230	160-240	590-830
	Total	830-1,080	460-700	490-710	1,770-2,480
High	Unconventional	1,100-1,440	610-930	650-940	2,360-3,300
	Conventional	460-600	260-390	270-390	980-1,380
	Total	1,560-2,030	870-1,310	920-1,330	3,350-4,680

Hatch Calculations. The values presented in this table are rounded to the nearest £ million. Numbers may not sum due to rounding. The lower bound represents a development scenario with low drilling intensity and sourcing assumptions. The upper bound represents a development scenario with high drilling intensity and sourcing assumptions.

Table 7.13 Average annual employment (FTE) impacts in NI by type of development activity and low, medium and high development scenarios.

Development Scenario	Type of development	Employment Impacts (Per Annum) within Northern Ireland			
		Direct	Indirect	Induced	Total
Low	Unconventional	10	5-10	5-10	20-30
	Conventional	5-10	5	5	15-20
	Total	15-20	10-15	10-15	35-45
Medium	Unconventional	20-25	10-15	10-15	40-55
	Conventional	10	5-10	5-10	20-30
	Total	30-35	15-25	15-25	60-85
High	Unconventional	35-50	20-30	20-30	80-110
	Conventional	15-20	10-15	10-15	35-45

	Total	50-70	30-45	30-45	110-155

Hatch Calculations. The values presented in this table are rounded to the nearest £ million. Numbers may not sum due to rounding. The lower bound represents a development scenario with low drilling intensity and sourcing assumptions. The upper bound represents a development scenario with high drilling intensity and sourcing assumptions.

GVA & Employment Impacts per well

7.35 As noted earlier, the total expenditure associated with each well is estimated to vary between £19.5 and £24.5 million depending on the drilling intensity, of which it is estimated £6.3-£9.4 million will be retained in Northern Ireland. The upshot is that GVA and employment which is estimated to be supported in NI per well is sizeable in its totality, but fairly modest when it is borne in mind that this could be spread over a period up to thirty years in duration.

Table 7.14 Total GVA and employment impacts in NI per well

GVA Impacts (£ millions) within Northern Ireland			
Direct	Indirect	Induced	Total
3.0-4.4	1.9-2.9	1.8-2.6	6.7-9.9
Employment Impacts (Person Years) within Northern Ireland			
Direct	Indirect	Induced	Total
45-60	25-40	25-40	100-140

Hatch Calculations. The values presented in this table are rounded to the nearest £ 100,000 and 5 FTE jobs. Numbers may not sum due to rounding. The lower bound represents a well with low drilling intensity and sourcing assumptions. The upper bound represents a development scenario with high drilling intensity and sourcing assumptions.

7.36 The average annual GVA and employment impacts per well supported in NI are shown in Table 7.15 below.

Table 7.15 Average annualised GVA and employment impacts in NI per well

GVA Impacts (£ millions) within Northern Ireland			
Direct	Indirect	Induced	Total
0.10-0.15	0.06-0.10	0.06-0.09	0.24-0.33
Employment Impacts (Person Years) within Northern Ireland			
Direct	Indirect	Induced	Total
1.5-2.0	0.9-1.3	0.9-1.3	3.3-4.6

Hatch Calculations. The values presented in this table are rounded to the nearest £ 10,000 and 0.1 of an FTE job. Numbers may not sum due to rounding. The lower bound represents a well with low drilling intensity and sourcing assumptions. The upper bound represents a development scenario with high drilling intensity and sourcing assumptions.

7.37 For the purposes of comparison with other studies the total average annualised employment impact per pad is estimated to be 7-9 FTE jobs for a conventional pad and 20-28 FTE jobs for an unconventional pad (this difference is explained by the higher number of wells per pad in the unconventional development scenarios). The total average annualised employment impact per lateral is estimated to be 1.1 to 1.6 FTE jobs.

7.38 Table 7.16 presents the comparative per lateral/well/pad employment impacts stated from other oil and gas impact studies (each study presents their development scenarios differently). The table below shows a wide variation in impacts when measured on a per lateral/well/pad basis. However, importantly, the employment impacts on NI are more in line with the more recent UK national studies which assessed the economic impact of oil and gas development on Wales and Scotland. This is expected as, of the studies presented below, the NI context is most closely aligned with the Welsh and Scottish context. In comparison, the larger employment impacts presented in the UK wide studies assumed much higher levels of retained expenditure (100% in one instance) on the basis of the future development of a major onshore sector.

Table 7.16 Comparison of the scale of NI employment impacts with other studies

Name of Study	Measurement basis (employment per lateral/well/pad)	Total Employment Per Annum (employment per lateral/well/pad)
UK - IoD	Employment per lateral at peak	185 (peak)
UK - EY	Employment per lateral at peak	161 (peak)
UK - DECC	Employment per lateral at peak	89 (peak)
Wales - Regeneris	Average FTE employment per lateral	1.3-1.5 (average)
Scotland - KPMG	Total FTE employment per well (peak) (central scenario)	5 (peak)
Northern Ireland estimates	Total annual average FTE jobs: - per pad (unconventional) - per pad (conventional) - per well - per lateral	(averages) 20-28 7-9 3.3-4.6 1.1-1.6

Note: total employment includes direct, indirect and induced for the study impact area

Development of the Supply Chain

7.39 There is the potential for the opportunities presented by the onshore oil and gas development in NI to encourage local businesses to invest in order to capture a greater share of associated expenditure. Likewise, the prospect of being closer to a developing market may also attract elements of the oil and gas supply chain to invest in Northern Ireland. This type of effect could in turn ensure a robust and reliable local supply chain for what would be a developing sector in Northern Ireland, as well as resulting in a higher share of capex and opex being captured in Northern Ireland.

7.40 However, the assessment assumes that the scale of the opportunity is not sufficient, even under the high scenario, for an effect of this type to be significant. The fact that there are currently moratoria in the rest of the UK and the Republic of Ireland will also reduce the confidence that key tier one and two suppliers, especially for major specialist equipment suppliers and operators, would have in making major investments into Northern Ireland.

Type of Employment and Skill Requirements

7.41 Development of oil and gas will create a demand for a wide range of both existing and different skills within the NI economy, both within the oil and gas sector and in other sectors of the economy. Whilst some of these skills existing in high volumes within NI and will be sourced locally, others will need to be sourced from further afield due to their specialist nature.

7.42 The types of jobs in the upstream oil and gas industry are generally highly skilled including the following types of jobs[74]:

- Drilling, Energy, Mining, Completions and Reservoir Engineers
- Wellsite and Engineering Geologists
- Geochemists and Geoscientists
- Mudloggers
- Instrumentation Technologists.

7.43 The analysis above shows the more closely defined employment and skills requirements of the oil and gas sector. However, development of oil and gas does not just draw upon the oil and gas sector. It covers a broader range of jobs and skills. For example, in the earlier stages of development there is significant requirements for inputs from the construction and planning sectors. KPMG's economic assessment of Scotland's oil and gas development presented a range of direct and indirect job types that are required in the unconventional development of oil and gas. These job types are shown in Table 7.17. This table helps illustrate the broader job requirements of oil and gas development if it were to take place in Northern Ireland.

Table 7.17 Employment categories and job type

Employment categories	Job Type
Planning and licensing	Environmental and regulatory approval
	Surface leasing and permits
	Site excavation, preparation
	Drilling
	Evaluation
Exploration	Geophysical and geochemical surveys
Pad Development	Designing well pad requirements
	Installing infrastructure
Drilling and Completion	Mobilising drill rig requirements
	Cementing casing into bore
	Sourcing and receiving drilling mud additives
	Drilling and installing production casing
Fracturing	Sourcing and receiving fracturing fluids
	Pumping fracturing fluids
	Treating/transport waste and wastewater
	Testing for recovery potential
Production	Confirming well viability
	Installing surface facilities
	Installing pipe infrastructure
Decommissioning and aftercare	Preparing site for decommissioning
	Decommissioning and aftercare

[74] Codovia, 2019, The Future of Oil and Gas Jobs and required Skills.

Source: KPMG, 2016, Economic Impact Assessment and scenario develop of unconventional oil and gas development in Scotland.

Indirect Economic Activity Supported in the Tourism & Hospitality Sector

7.44 In addition to the economic impacts estimated above which are focused on direct retained expenditure within Northern Ireland, there will also be additional indirect economic impacts supported in the tourism sector associated with the local (within Northern Ireland) expenditure of transitory oil and gas workers[75]. For example, transitory workers will spend money on food and accommodation whilst working within Northern Ireland. This will indirectly support jobs and create economic value within the tourism sector. These economic impacts are not included in the induced expenditure impacts estimated above.

7.45 Transitory workers are likely to be heavily used in the activities associated with drilling and hydraulic fracturing. This is due to the lack of these specialist skills, equipment and associated services within Northern Ireland. The estimated expenditure per well occurring outside of NI associated with these activities is around £7.62m assuming low drilling intensity and £10.37m assuming high drilling intensity (of which £1.52m and £2.07m will be the employments costs of the transitory workers).

7.46 The economic impacts within NI associated with transitory workers will occur in the period that their services are required, mainly during the initial exploratory drilling, the subsequent main drilling and fracking of the wells, as well as subsequent drilling and fracking of established wells to improve their productivity.

7.47 The estimated indirect economic activity supported in the hospitality, food and drink, and retail sectors is presented in Table 7.18 below. Whilst the economic benefit supported is fairly modest, it can nevertheless provide a valuable injection of spending and help to support new jobs in local communities. To put the estimates in context, under the highest development scenario only around 2 FTE jobs would be supported per year in the communities in close proximity to each development pad[76] .

[75] Transitory workers are assumed to live outside of Northern Ireland. The expenditure of these workers is not captured within the core economic impacts.

[76] 200 person years of employment corresponding to the high development-high intensity scenario divided by nine pads divided by 12 years over which the associated activities would be concentrated. The royalties have been estimated net of UK corporation tax.

Table 7.18 Total Indirect Economic Activity Supported in the Tourism Sector

	Total indirect person years of employment (FTEs) supported within Northern Ireland	Total indirect GVA (£m) supported within Northern Ireland
Low Development Scenario	40-60	£1.4-1.9
Medium Development Scenario	80-110	£2.4-3.3
High Development Scenario	150-200	£4.6-6.3

Hatch Calculations, 2021.

Financial Contribution to Communities

7.48 The UK Onshore Operators Group's Community Engagement Charter in 2013[77] sets out the commitments made by its members:

- To provide benefits to local communities at the exploration/appraisal stage of £100,000 per well site where hydraulic fracturing takes place
- To provide a share of proceeds at production stage of 1% of revenues, allocated approximately 2/3rd to the local community and 1/3rd at the county level.

7.49 Under the assumption that development in Northern Ireland will follow the same commitments as laid out above, Table 7.19 shows the potential contribution to communities from oil and gas development in Northern Ireland. The community benefits at the production phase are calculated based on the estimated output of oil and gas from Northern Ireland and then estimating how much revenue would be generated from this output. The estimates for the revenue generated at the production stage are based on a range of a conservative price of $40 per barrel and an optimistic price of $60 per barrel. The ranges presented in the table also account for the uncertainty over the intensity of drilling that would occur in Northern Ireland.

Table 7.19 Contribution to Communities

	Development Scenarios		
	Low	Medium	High
Exploration/Appraisal Stage			
Local community benefits at the exploration/appraisal stage of £100,000 per (lateral) well site where hydraulic fracturing takes place (£m)	1.2	2.4	4.8
Production Stage			
Community benefits at production stage allocated at the local community level (£m)	*1.2-6.9*	*2.4-7.2*	*4.8-14.4*
Community benefits at production stage allocated at the county level (£m)	*0.6-3.5*	*1.2-3.6*	*2.4-7.2*
Total community benefits at production stage (£m)	1.8-10.4	3.6-10.8	7.2-21.6
Development Lifecycle			
Total community benefits (£m)	3.0-11.6	6.0-13.2	12.0-26.4

[77] Benefits of Onshore Oil and Gas | UKOOG

Hatch Calculations, 2021. The ranges presented reflect low to high drilling intensity scenarios and low to high oil price estimates. Numbers are rounded to the nearest £0.1m. Numbers may not sum due to rounding.

Wider Economic Impacts

Energy Supply and Security

7.50 In total, around 47,000 GWh of energy was consumed in NI in 2017 (13,754 GWh from electricity and gas and 33,286 GWh from other fuels). This was equivalent to 3.3% of the total energy consumption in GB for the same year. Of this energy, 50% was for Heat, 33% was for Transport and the remaining 17% was for Power.

7.51 NI has three main power generating sites with an installed capacity of 1.9 GW (1.2GW of which is gas powered), as well as renewable energy sources (with capacity of over 1.3GW from wind alone). Kilroot, the coal and oil powered station, is due to be converted to a gas only generator. There is also interconnections with the Scottish grid, with two 250 MW lines on the Moyle Interconnector and interconnection with the Republic of Ireland grid is via three tie-lines with over 400 MW combined capacity. Whilst electricity can be imported and exported via the Moyle Interconnector and North-South tie-lines, since 2016 NI was able to meet the vast majority of its own electricity demands without relying on imports or transfers of electricity from other countries.

7.52 Electricity consumption in NI has declined between 2010 and 2019 (-8%) due to improved energy efficiency, extension of gas networks especially for domestic heating, changes in the building stock which has improved energy efficiency, as well as higher prices which have dampened demand. The contribution of renewables sources of electricity from within NI as a share of total consumption has gradually increased between 2010 and 2020, reaching just under 50% in September 2020.

7.53 There are four gas transmission pipelines covering Northern Ireland. All of Northern Ireland's gas comes from the UK mainland via the Scotland to NI Pipeline (SNIP). The gas distribution network provides gas to three distribution areas: Phoenix Natural Gas Limited (PNGL) operates the network in the Greater Belfast and Larne distribution licenced area; firmus energy (Distribution) Limited (feDL) operates the network in the 'Ten Towns' distribution licenced area; and SGN Natural Gas Limited (SGN) operates the network in the West distribution licenced area.

7.54 The total number of gas connections in NI has gradually risen as new investments have been made in the network, mostly recently in the west. Total gas consumption in the domestic and industry and commercial sectors in NI was 6,754 GWh in 2019. Two thirds (68%) of total consumption in 2019 was in the Greater Belfast network area with about 27% in the Ten towns licenced area and the remaining 5% in the West network area. Over the period 2017-2019 there was a 14% rise in total consumption (an increase of over 806 GWh), continuing the trend of increased connections and consumption.

7.55 The Northern Ireland Gas Capacity Statement forecasts the level of gas demand and supply up to 2028/29. This indicates an overall fall in demand primarily due to the increasing contribution of renewable sources within the power generation sector (and as existing capacity is taken off stream). The demand amongst domestic, commercial and industrial users (distribution) is forecast to increase gradually, reflecting increasing market penetration of natural gas as a fuel within the domestic and industrial/commercial sector (and allowing domestic and non-domestic investment in renewable heating and energy efficiency measures).

7.56 The Northern Ireland Department for the Economy is currently preparing its Energy Strategy which will set out possible pathways to net zero carbon energy, including the contribution which natural gas can play as part of this transition. The strategy options were published in March 2021, with the full strategy due to be published in late 2021.

7.57 Whilst the strategy will help to inform energy planning and investment decisions, the likelihood is that natural gas will continue to play an important part of the energy mix in NI and as part of the transition to net zero carbon energy (subject to which scenario option is selected and the associated rate of transition away from natural gas). A domestic source of oil and gas from onshore production could provide up 3.2 mmboe per year under the low development scenario (equivalent of 13% of NI demand in 2018), 3.9 mmboe under the medium scenario (15% of NI demand) and 7.1 mmboe under the high development scenario (28% of NI demand).

7.58 This supply of gas could be integrated into the gas network, meeting the needs of domestic, non-domestic and power generators, or transported by road to end users. This would help to reduce the long-term reliance on gas supply from Great Britain via the SNIP. This could also in turn help to reduce the risks associated with any potential disruption to the supply of imported gas although this is considered to be a modest risk.

7.59 As GB's supply of natural gas from the continental shelf declines, it will become increasingly reliant on imported LNG. NI will in turn rely on transhipped LNG, although neither it nor the Republic of Ireland currently have LNG facilities.

Energy Prices

7.60 The unconventional energy revolution in the US has put downward pressure on energy prices for the US consumers. Wellhead prices for US natural gas were trading $2.80 Mbtu in March 2021 compared to around $4 Mbtu[78] in late 2013 and $8 Mbtu in 2008. Lower natural gas prices also translate into a reduction in electricity prices, although the impact for consumers has been less dramatic than that which has occurred in the wholesale gas market for electricity generators. The regions in the US with the highest natural gas extraction tend to have the lowest electricity price and vice versa. This is a particularly important factor for energy intensive businesses.

7.61 Globally, oil and gas prices were relatively low pre-Covid-19 pandemic due to the increased supply from North America, as well as strong supply from the OPEC countries and other countries such as Russia and Venezuela. In March 2021 the Brent spot price was $65.24 per barrel, whilst NBP 1 day ahead was £40.60 per therm having increased from their historic lows in the first and second quarter of 2020 (and close to the trend over the last decade).

7.62 Energy costs in NI are typically higher than the rest of the UK and EU averages. In the first half of 2019, non-domestic electricity prices were above the EU median price in all size categories - they were substantially above the EU median price in the small category (15% higher), small/medium category (41% higher), the medium category (37% higher) and in the large/very large category (40% higher).[79] Whilst there is limited published data for gas prices, domestic gas prices were slightly above UK prices and below most EU countries.

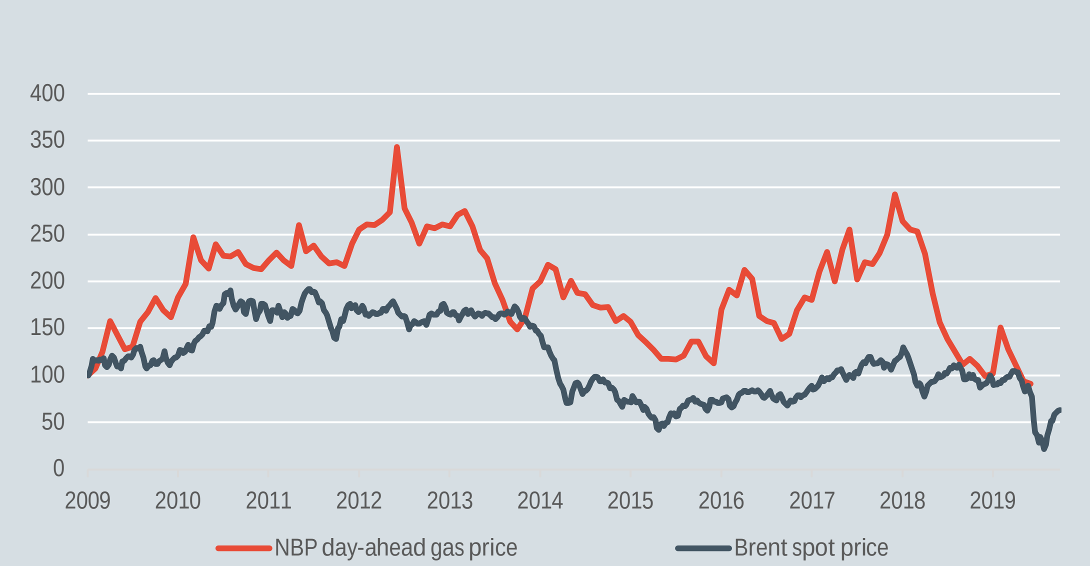
7.63 Whilst NI would undoubtedly benefit economically from lower energy prices, it is relatively unlikely that future gas production in NI from onshore sources will provide the type of price effect experienced in the US. The main reason for this is that the costs of production will be relatively high for developers in Northern Ireland, even under the scale of activity envisaged

[78] one thousand British thermal units

[79] Energy in Northern Ireland 2020 (economy-ni.gov.uk)

under the high development scenario. There is the potential for this to change in the future, if imported LNG becomes a bigger part of the energy mix, although this is currently uncertain.

Figure 7.2 Indexed Brent Crude Oil and NBP Gas Prices, October 2009 = 100



Sources: U.S. EIA; Ofgem

7.64 Northern Ireland's supply of electricity and gas is closely intertwined with that of the UK, and to some extent the Republic of Ireland. In terms of the supply of gas, it operates in markets where prices are largely set at a European level and the cost of transportation is relatively low. It is unlikely that the supply of oil and gas will significantly reduce the prices that major non-domestic users pay for their energy, or the price of gas or electricity to domestic consumers.

Potential Indirect Impacts on Sectors

Downstream Sectors

7.65 The production of large scale oil and gas could be a benefit to downstream sectors, which use these as a feedstock to their existing production activity. The feedstocks can include a mixture of light hydrocarbons including ethane, propane and butane. This could enable producers to replace imported feedstocks, reducing the associated transportation or transfer costs.

7.66 The available GSNI evidence suggests that ethane and propane are not likely to be found in the shale of Fermanagh. All of the wells drilled to date which have had shows, were dominated by C1 Methane. The wet gas condensate that has enabled some shale gas to command a higher price and to be more economical is less likely in NI.

7.67 The economic framework which has been used in the economic impact analysis above does not account for the impact of the additional oil and gas output on other sectors in NI (in for example the way that a CGE economic model would). However, besides the power generation sector, NI lacks the types of sectors which would be a ready source of demand for the oil and gas output. NI lacks a petrochemicals sector and its basic chemicals sector is modest in size. Official employment and GVA data for the petrochemicals and chemical sectors[80] is not disclosed due to the small number of businesses.

7.68 It also lacks the major energy intensive sectors, such as steel-making and glass manufacture, which might require a major source of cheap energy as part of its manufacturing processes. It does have a number of medium sized manufacturers of construction materials. These could potentially have an interest in bilateral agreements with site operators.

7.69 Allowing for these considerations, the prospect of a local source of feedstocks for the manufacturing sector or gas for power generation is unlikely to provide a major driver for additional sector growth (although it could safeguard employment given the cost pressures firms in these sectors face) or attract major new inward investment into Northern Ireland.

Tourism Sector

7.70 There is limited evidence examining the tourism impacts of energy infrastructure in the UK. The exceptions to this have tended to focus on onshore wind farms and electricity and gas transmission infrastructure (for example, a study undertaken by National Grid examining the impact of major grid infrastructure on the visitor economy and recreational users[81]). The limited development of onshore oil and gas to date means that the assessments which have been undertaken are few in number and typically restricted to ex-ante EIA type assessments. A number of the strategic area-based assessments which have been undertaken do consider tourism impacts, whilst others have not covered this topic.

7.71 Assessments for individual developments (such as the Environmental Statement for exploration activity around Preston New Road in Lancashire) tend to consider impacts which may indirectly affect the tourism sector (such as visual, noise, traffic and air quality impacts) whilst not directly assessing the impacts on visitors and tourism. This may reflect the sites not being in established tourism areas.

7.72 The international evidence considering the potential impacts on visitor perceptions, experiences and behaviour, and hence the tourism sector overall, is also limited. The comparability to NI is also limited due to the considerable scale of the exploration and production activity in these areas, whilst often not being located in well-established visitor and tourism areas. Nevertheless, the research provides some general messages:

- There is the potential for temporary expenditure benefits for the tourism sector during the exploration and drilling phases in particular associated with the temporary workforce undertaking specific specialist tasks (such as drilling, hydraulic fracturing, etc). The benefits are concentrated in local towns through spending in hospitality, food and drink, retail and leisure sectors. *As noted, the estimate of this additional economic benefit associated with this expenditure for NI is very modest.*
- Scope for longer-term negative effects on tourism sectors where development activity occurs at scale and is fairly concentrated in particular areas. These impacts may occur through the indirect consequences of sector capacity being concentrated on migrant workers (displacing more traditional visitors) and the possibility of discouraging long term investment. *In the case of Northern Ireland, the potential scale of development, its*

[80] SIC 19: Manufacture of coke and refined petroleum products and SIC 20.14: Manufacture of other organic based chemicals

[81] A Study into the Effect of National Grid Major Infrastructure Projects on Socio-economic Factors - Business and Recreational Users Report. February 2014

likely dispersed nature and the modest expenditure impacts, are not likely to lead to these types of effects occurring.

- Other research points to the potential for negative impact of onshore oil and gas development on visitor perceptions of areas, especially amongst visitors who value high quality environments. A meta review of US peer-reviewed studies reaches the conclusion that whether fears of environmental contamination are realistic or not, there could be a permanent, negative impact on public perceptions of a rural area with a significant tourism sector. *The areas in which onshore oil and gas development could take place in NI coincide with a number of established tourism areas or areas prioritising the growth of the sector, including a range of visitor attractions and recreational assets. Some of these are of international importance. A common feature of the branding and promotion of these tourism areas is the quality and unspoilt character of the rural environment.*

7.73 It is unlikely that the influx of migrant workers or associated local economic growth driven by oil and gas developments will lead to major positive or negative impacts in its own right. Rather, the risk of negative impacts arise from the specific relationships between the location and characteristics of particular developments, the locations in which they are planned, and the nature of their tourism offer and branding. The research evidence points to both established tourism and aspiring areas with high quality landscapes and environments which are a key feature of their visitor offer, and which brand themselves on their peace and tranquillity, as being the area which are much more likely to be sensitive to development.

7.74 Areas which are located in areas with higher concentration of oil and gas resources include Lough Neagh (Lough Neagh Basin), County Fermanagh (NWICB), the Causeway Coast (Rathlin Basin) and the areas of the East Coast (Larne Basin). A number of these include areas which are known for their scenic landscapes and strong tourism offer:

- Lough Neagh - The lough is the biggest lake in the UK and is known for its tranquil character which makes it a popular visitor area. Lough Neagh attracts bird watchers from all over the world due to the number and variety of birds which can be seen on its shores. The Lough has undergone substantial positive changes over recent years assisted by substantial EU support through the Lough Neagh Partnership. Watersports is popular on the lough, centred around the award winning Ballyronan marina and a Blue Flag beach award. Other popular activities undertaken in the area include cycling, adventure sports, guided tours, golf and walking & hiking[82].
- County Fermanagh - Almost a third of County Fermanagh is covered by lakes and waterways of all shapes and sizes. This ranges from the larger Upper and Lower Lough Erne, to the Shannon-Erne Canal and the River Erne. This makes County Fermanagh attractive to visitors engaging in walking, cycling, boating, kayaking, canoeing, wildlife watching and heritage visits and visitors looking to take in the wildlife of the County. Other attractions include the Cuilcagh Legnabrocky Trail, Marble Arch Cave UNESCO Global Geopark, and castles [83].
- Causeway Coast and Glens - The rugged, unspoilt landscape presents opportunities for a range of activities. The area is home to iconic attractions along the Causeway Coastal Route, for example the Giant's Causeway UNESCO World Heritage Site. Tourism is a key economic activity and a major prosperity driver for the area. The number of estimated

[82] https://www.discoverloughneagh.com/

[83] https://discovernorthernireland.com/destinations/county-fermanagh

overnight trips to the Causeway Coast and Glens Borough in 2019 was 1,095,000 and an estimated expenditure on overnight trips of £192 million in 2019[84].

- East Coast (Mid and East Antrim) – Mid and East Antrim is home to rugged coastlines, castles and hosts the former homes to two US presidents. The Gobbins is a famous hike in the area allowing visitors to navigate through hidden tunnels and go up and down staircases which have been carved into the cliff face[85].

Agriculture and Other Land Based Sectors

7.75 Agricultural land use is a major feature of Northern Ireland's current land use. In 2019, over 1 million ha were used for agriculture, 75% of its total land area[86]. In 2017, there were 25,000 farms across NI, of which the south-west of NI contains the highest numbers with over 5,000 farms in the district of Fermanagh and Omagh[87].

7.76 NI also has eight forestry planning areas and 19 forest landscape units[88]. There are high concentrations of forestry in the West Fermanagh Uplands and Antrim Hills and Glens, whereas the area around Lough Neagh has less forested areas.

7.77 There is also a small but growing food-based visitor economy associated with this agricultural nature and public perception of high-quality environment and associated food products. This is confirmed by the UGEE JRP all island study which notes that the agri-food sector is currently acknowledged to be on a path of sustainable growth, based on emission-efficient food production and high animal welfare, environmental and agronomic standards.

7.78 The land takes under the development scenarios is an estimated 9 hectares for the low development scenario, 15 ha for the medium scenario and 27 ha for the high scenario. This represents a modest loss of agricultural land (or potentially forestry) across NI as a whole. Whilst the change in use will result in a fall in incomes from agricultural use, for the landowners affected it would be compensated through rental income for the land.

7.79 Stakeholders engaged during the research pointed to the potential reputational damage for the rural economy associated with change in use, perceptions about the potential for contamination and the knock-on this may have for the agri-food and growing food tourism sectors. This is covered further in the environmental impact sections below.

Other Indirect Costs

7.80 Onshore oil and gas development in NI may also lead to a range of other financial and economic costs for the public sector. This includes the costs managing the licensing and consenting process within government departments, regulators, local government and other local bodies. It also extends to the costs associated with policing demonstrations and other public services.

[84] https://www.causewaycoastandglens.gov.uk/see-do/visit-causeway-coast-and-glens

[85] https://www.mynewsdesk.com/uk/meabc/pressreleases/tourism-figures-reveal-upward-trend-for-mid-and-east-antrim-2902567

[86] https://www.daera-ni.gov.uk/sites/default/files/publications/daera/Stats%20Review%202019%20final.pdf

[87] http://www.ninis2.nisra.gov.uk/InteractiveMaps/Agriculture%20and%20Environment/Agriculture/Farm%20Census/atlas.html

[88] Department of Agriculture, Environment and Rural Affairs, Forestry Planning Areas and Forest Landscape Units, 2018

Whilst it is very difficult to put an estimate of these potential costs, the NAO[89] has identified the known public expenditure of at least £33 million in England since 2011 (not including the cost of planning appeals, judicial reviews, or the time of public servants). This includes £13.4 million spent by three local police forces on managing protests around shale gas sites. The NAO notes that BEIS has not estimated the public investment that would be required to support the production of shale gas at scale in England.

Summary

7.81 The approach to assessing the potential economic impact of onshore oil and gas in NI has consisted of:

- The assessment of the direct, indirect and induced GVA and employment impacts supported by the different development scenarios, distinguishing between wells for conventional and unconventional resources, higher and lower drilling intensity, and different phases of activity
- Use of best estimates of the level of retained expenditure in NI, which is informed by analysis of the supply chain inputs and skills that will be required and the ability of the NI economy to meet these in the coming decades (this does not take account of economic impacts associated with the onward marketing and sale, transport and distribution of the oil and gas output)
- The use of Hatch's input-output tables for NI to estimate the supply chain and personal expenditure effects (indirect and induced effects respectively)
- The presentation of the total economic impacts over the 30 year assessment period, as well as average annual estimates.

7.82 The analysis points to the following main impacts:

- Under the No Development Scenario there is no additional economic benefit.
- The annual GVA impact ranges from £2.2m-£3.3m under the low scenario, £4.0m-£6.0m under the medium development scenario and £7.6m-£11.3m under the high development scenario.
- The annual FTE employment impact ranges form 35-45 jobs under the low scenario, to 60-85 jobs under the medium development scenario and to 110-155 jobs under the high development scenario.

7.83 When comparing to the energy sector as a whole and the low carbon and renewable sectors the scale of impacts are shown to be relatively low. The fairly modest scale of economic impact can largely be attributed to the combination of the scale of development and the relatively limited scope to capture the associated expenditure within Northern Ireland, although the high development scenario has assumed a much higher number of developments, the analysis does not suggest that NI could capture an onshore oil and gas hub which could retain the higher value expenditure associated with horizontal drilling and fracking and associated services.

7.84 The assessment also estimates the indirect tourism impacts which arise from the expenditure of transitory workers on hospitality, food and drink, and retail in the local communities neighbouring the developments. These are not included within the core impacts presented above. The estimated tourism impacts are relatively low for all development scenarios. Under

[89] Fracking for shale gas in England (nao.org.uk)

the highest development scenario only around 2 FTE jobs would be supported per year in the communities in close proximity to each development pad.

7.85 The study provides insights into the type of employment and skills requirements that would be required if oil and gas were to be developed in Northern Ireland. Development of oil and gas would create demand for employment and skills directly within the oil and gas sector (for example requiring engineering and geology skills) and also create demand for wider skills and employment (for example in planning and construction). The report gives examples of the wide range of job types required within NI ranging from highly skilled engineering to semi-skilled jobs.

7.86 The production of large-scale oil and gas could be a benefit to downstream sectors, which use these as a feedstock to their existing manufacturing and energy generation. However, besides the power generation sector, NI lacks the downstream sectors and major energy intensive sectors which would be a ready source of demand for the oil and gas output. The benefit of cheaper feedstocks for the manufacturing sector or gas for power generation is unlikely to provide a major driver for additional sector growth (although it could safeguard employment given the cost pressures firms in these sectors face) or attraction of major inward investors into Northern Ireland.

7.87 Energy costs in NI are typically higher than the rest of the UK and EU averages, in part due to its reliance on imports. This reduces the competitiveness of the region's industry and deters inward investment. Whilst NI would undoubtedly benefit economically from lower energy prices, it is relatively unlikely that future gas production in NI from onshore sources will provide the type of price effect experienced in the US. The main reason for this is that the sector will not be able to achieve the economies of scale and low costs of production in Northern Ireland, even under the scale of activity envisaged under the high development scenario.

7.88 Agricultural land is a major feature of Northern Ireland's current land use and a valuable economic sector. There is also a small but growing food-based visitor economy associated with this agricultural nature and public perception of high-quality environment and associated food products. The land take under all development scenarios is modest and landowners would be compensated for any associated loss of income. However, there is the potential risk of reputational damage for the rural economy associated with change in use, perceptions about the potential for contamination and the knock-on this may have for the agri-food and growing food tourism sectors (all concerns expressed by local stakeholders in areas which could be affected by development).

7.89 The development of onshore oil and gas in NI would also incur other financial and economic costs by the public sector. The NAO in a report focused on England notes that whilst the costs associated with activity at scale are highly uncertain, these costs would nevertheless arise and need to be accounted for.

Part C

8. Social and Environmental Impact Method

8.1 The environmental and social impact assessment of the potential for onshore petroleum exploration and development in NI draws on:

- Development scenarios which have been used to consider the potential scale of development for both conventional and unconventional resources in NI between 2021 and 2050, including a 'no development' scenario
- In terms of the assumed high and low ranges for drilling activity for each development scenario, the use of the higher intensity as this represents the worst case in environmental impact terms
- A combination of qualitative and quantitative evidence drawn from existing Strategic Environmental Assessments (SEAs) in the UK and other publicly available research reports covered in the review
- An analysis of the baseline conditions in NI, across both environmental and socio-economic topics
- Engagement with stakeholders to provide insights about potential impacts and issues of particular relevance to the NI context.
- A consistent approach has been adopted to the assessment of environmental and social impacts and the evaluation criteria used to determine impact of significance. These criteria assume:
  - Prevailing planning policies and environmental regulations control activities are sufficient to prevent pollution and nuisance to sensitive receptors, and
  - Mitigation measures outlined at the end of the assessment of each receptor should be implemented, among others, as part of the licence conditions and as good industry practice.

8.2 Prevailing planning policies and environmental regulations control activities to prevent pollution and nuisance to sensitive receptors. As such, planning policies and environmental regulations provide high-level mitigation that is common to all oil and gas development, while good practice measures provide site-based mitigation. The significance assessment can therefore be considered as a <u>post-mitigation assessment</u> that, where possible, takes into account the areas of uncertainty raised in the SEAs for unconventional oil and gas extraction across the UK and NI specific research reports (in particular those related to particular types of impacts, as well as existing controls and regulatory systems that will act to control potential environmental and social impacts). <u>Assessing the effectiveness of the implementation and regulation of past, current or future planning policies and laws in NI is not however within the scope of this assessment</u>.

8.3 Direct and indirect, positive and negative (adverse) impacts have been considered.

8.4 A qualitative assessment has been conducted exercising the professional experience and judgement of the project team and drawing on the range of evidence gathered during the study. Where there are limitations to the data, and / or uncertainties with regard to the assessment of significance, these have been recorded along with any material assumptions.

8.5 The scope is based on the following stages of oil and gas exploration and development activity:

- Stage 1: Development and Exploration, including surveying, site selection and planning (up to 3 years)
- Stage 2: Drilling, Fracturing and Waste management, including site preparation, drilling and testing (up to 2 years)
- Stage 3: Production and Operations (10-15 years)
- Stage 4: Decommissioning, Restoration and Aftercare (6 months to a year)

8.6 Transboundary and cumulative impacts are also addressed, where appropriate.

Environmental, Social and Socio-economic Impact Themes

8.7 The impact assessment covers the following potential environmental and social impact themes and topics (in no particular order of importance):

- Air Quality: Direct and fugitive emissions, construction and site traffic, dust and associated air quality impacts
- Water: Groundwater and surface water abstraction and pollution of groundwater and surface water bodies
- Naturally Occurring Radioactive Materials (NORM): including the occurrence of radon at sites
- Soil: land take, ground contamination, soil sealing and quality
- Climatic factors: GHG emissions from land use change and combustion of fossil fuels
- Biodiversity, flora and fauna: habitat disturbance, loss and fragmentation, loss of flora and fauna and invasive non-native species
- Population: noise, light, air quality/dust, felt seismic activity, in-migration and impacts on social cohesion
- Public health: amenity, mental wellbeing, recreation and physical activity, physical health and safety, road traffic accidents
- Cultural and archaeological heritage: loss/damage to known or unknown sites or assets, impacts on setting of cultural heritage
- Landscapes and geodiversity: landscape and visual effects, natural tourism assets
- Material assets: land use change, impacts on industrial/agricultural land, impacts on infrastructure, impacts on housing and services, impacts on tourism and visitor economy infrastructure.

8.8 It is important to acknowledge that many potential impacts are site-specific and will vary depending on the sensitivity of local receptors and the prevailing environmental and social conditions. Within the scope of this study, it is challenging to assess these beyond high level or general terms, and the assessment does not include explicit statements about receptors and potential impacts for specific sites and their neighbouring communities which could be the focus of future development applications.

8.9 The assessment uses a framework derived from the literature on impact assessment to provide a consistent method, comprising three elements, within which to consider impacts and significance:[90,91,92,93]

- Receptor sensitivity
- Nature of the impact
- Significance of the impact.

Identifying Receptor Sensitivity

8.10 Receptor sensitivity has been determined from the importance or value of the social or environmental aspect under examination. Sensitivity is a measure of the adaptability and resilience of an environmental or social receptor to an identified impact, in the context of the prevailing regulatory and planning systems. Sensitivity has been defined as:

- Low: The receptor is adaptable and is resilient to change
- Medium: The receptor has a degree of adaptability and resilience and is likely to cope with the changes caused by an impact, although there may be some residual modification as a result
- High: The receptor is vulnerable, rare, threatened or at risk due to its location or setting (context) and an impact is likely to leave it in an altered state from which recovery would be difficult or impossible.

The Nature of Impacts

8.11 In determining the significance of the impact it is important to take into account and consider several factors which define the nature of the impact, namely the:

- Type of impact
  - Positive: Applies to impacts that have a beneficial environmental or social result, such as enhancement of the existing environmental or social conditions
  - Negative: Applies to impacts that have a harmful aspect associated with them such as loss or degradation of environmental resources, nuisance to people or impact on amenity.
- Impact Path

[90] United Kingdom Environment Agency. *Environmental Impact Assessment (EIA): A handbook for scoping projects.* 2002. Environment Agency.

[91] Canadian Environment Protection Agency. *Determining Whether a Designated Project is Likely to Cause Significant Adverse Environmental Effects under the Canadian Environmental Assessment Act, 2012 — Interim Technical Guidance*. Version 1. March 2018

[92] World Business Council for Sustainable Development. *Guidelines for Environmental and Social Impact Assessment*. 2016. Cement Sustainability Initiative.

[93] FEARO. *A Reference Guide for the Canadian Environmental Assessment Act. Determining Whether a Project is likely to Cause Significant Adverse Environmental Effects*. November 1994. Federal Environmental Assessment Review Office.

  - Direct: Applies to impacts which can be clearly and directly attributed to a particular environmental or social parameter (e.g. generation of dust directly impacts air quality)
  - Indirect: Applies to impacts which may be associated with or are subsequent to a particular impact on a certain environmental or social parameter (e.g. dust dispersion away from a site may lead to vegetation or crop damage).
- Duration (how long the stressor or its effect will last)
  - Short-Term: Applies to impacts whose effects on the environment will cease within a 1 year - period, or once construction activities are completed
  - Medium-Term: Applies to impacts whose effects on the environment will cease to be discernible within a 5-year period
  - Long-Term: Applies to impacts whose effects on the environment will be discernible for a period greater than 5 years.
- Reversibility
  - Reversible: Applies to impacts whose effects will be reduced and disappear over time (either naturally or artificially), once the impacting activity ceases
  - Irreversible: Applies to impacts whose effects will not be reduced or disappear over time (either naturally or artificially), once the impacting activity ceases.

Assessing the Significance of the Impacts

8.12 The concept of 'significance' is central to the impact assessment process and aids the identification and categorisation of environmental and social effects. Significance is a complex measure based on a combination of:

- Consequence, in combination with
- Likelihood of occurrence.

8.13 Consequence refers to the outcome that is determined by the nature of the impact on environmental and social receptors relative to thresholds such as sensitivity. Consequence may be:

- Positive: A beneficial effect on the receptor or receptors
- Negligible: whilst there may be a minor effect this will be below a threshold which is either noticeable or perceived by the receptor
- Minor: When compared with the baseline, change which may only just be noticeable; existing thresholds would not be exceeded
- Moderate: Change which may be noticeable and may breach accepted limits
- Major: A large change compared to variations in the baseline; potentially a clear breach of accepted limits.

8.14 Likelihood of occurrence is an expression of uncertainly and can be described as:

- Certain: The impact will invariably occur and can definitely be anticipated as resulting from the activity undertaken

- Likely: The impact will occur and can reasonably be anticipated as resulting from the activity undertaken
- Unlikely: The impact will seldom occur and may not necessarily be anticipated as resulting from the activity undertaken
- Very unlikely: The impact is not expected and not anticipated as resulting from the activity undertaken

8.15 Based on the factors above, a significance rating is given to each potential impact. The table below illustrates the rankings of impact significance based on the denoted categories of consequence and likelihood. The significance of the impact is then ranked as negligible, minor, moderate or major (adverse or positive) which is explained and justified using the results of the review and/or professional judgement.

Table 8.1 Significance Ranking Matrix

Consequence \ Likelihood	Very Unlikely	Unlikely	Likely	Certain
Positive	Negligible	Minor Positive	Moderate Positive	Major Positive
Negligible	Negligible	Negligible	Negligible	Negligible
Minor	Negligible	Minor Adverse	Moderate Adverse	Moderate Adverse
Moderate	Negligible	Moderate Adverse	Moderate Adverse	Major Adverse
Major	Minor Adverse	Moderate Adverse	Major Adverse	Major Adverse

Cumulative Impacts

8.16 Cumulative impacts result from the incremental impact of a project when added to other existing, planned or reasonably defined developments that, taken together at a defined temporal or spatial scale, result in physical, biological or social effects that are substantially greater than that of the stand-alone projects in isolation.

Transboundary Impacts

8.17 Transboundary impacts are impacts that extend beyond the host country of the project but are not global in nature. In this instance, transboundary impacts include air quality, abstraction from water sources, the pollution of surface and groundwater water bodies.

Approach to Mitigation

8.18 For each impact topic, mitigation measures have been identified from the existing evidence base which describe the possible steps and measures that could be taken to protect environmental and social receptors. It is assumed that the existing land use planning controls and environmental protection regulations provide effective mitigation at a strategic level, and mitigation measures, when undertaken for specific projects as good practice, typically further reduce impact significance. Where appropriate, the types of appropriate mitigation measures are specified for the different stages of onshore petroleum exploration and development.

Assumptions

8.19 The environmental and social impact assessment is based on the following assumptions:

- This is a high-level assessment of potential impacts. It is neither a Strategic Environmental Assessment (SEA), a project-level Environmental Impact Assessment (EIA), nor a project-specific Environmental and Social Impact Assessment (ESIA). Similarly, the assessment of health themes is not a Health Impact Assessment (HIA).
- Whilst the assessment is at the level of NI, it seeks to take account of the characteristics of the broad areas in which conventional and unconventional resource is more likely to occur due to the geological conditions. However, it is not a site-specific assessment.
- The assessment draws on published research mainly from the UK, as well as internationally (within the limitations of the available study resources). Key documents used in the assessment include the SEAs produced for the UK and for Scotland, as well as the EPA-led UGEE JRP all island study. However, due to the limited scale of recent unconventional oil and gas developments in the UK, the available evidence is reliant on desk studies, evidence from outside of the UK, evidence produced during conventional petroleum production and evidence from comparable industries. Therefore, current studies are seldom specific to individual geographic regions, nor considered in the context of the regional policy and legislative landscape.
- The assessment has been undertaken with reference to the prevailing regulatory and planning policy landscape of NI, and impacts have been considered within this context. A summary has been provided in section 2.
- A number of consultations were undertaken to inform this assessment, including with stakeholders at DAERA, Department for Infrastructure, as well as a number of environment and community groups. These meetings were to provide insights into potential issues of particular relevance to NI and were not intended as a formal consultation.

Structure of the sections

8.20 The following sub-sections provide a summary of the environmental, social, health and safety impacts of onshore petroleum exploration and development for those topics which have been scoped into the assessment (they are not presented in order of priority or importance). For each impact theme, the remainder of the Chapter discusses:

- Potential sources of impact during oil and gas activities
- Description of impacts by impact topic
- Evaluation of impacts by impact topic
- Impact mitigation by impact topic
- Summary table of the impact theme and associated topics.

8.21 Where the impacts are expected to be significantly different between developments of conventional and unconventional resources, this is noted.

9. Air Quality

9.1 This section covers the following:

- Point source and fugitive emissions
- Air quality impacts from construction and site traffic
- Dust.

Point source and fugitive emissions

Sources

9.2 Point source emissions to air are generated by onsite machinery (stationary and mobile), transportation, drilling, venting and flaring activities.

9.3 Fugitive emissions from conventional oil and gas activity are primarily generated by machinery, drilling and site related transportation. For unconventional activity, the potential for fugitive emissions is increased as a result of hydraulic fracturing, flaring and venting activities.

9.4 The DECC Report (DECC, 2013) discusses intentional vented emissions of methane and carbon dioxide associated with shale gas exploration and production, specifically the release of gases during flowback, and release for safety reasons and during certain maintenance operations.

9.5 Fossil fuel combustion in engines (such as diesel engines used for drilling, truck traffic, hydraulic fracturing and natural gas compression) and the flaring of shale gas generates mainly carbon dioxide. Incomplete combustion results in additional emissions such as methane, VOCs and carbon black, all of which have impacts on air quality.

9.6 Multiple truck movements occur during the well lifecycle, including transport of fresh water, additives, proppant and flowback water.

9.7 Indirect emissions result from processes used in the exploitation of shale gas, including emissions from the energy used to treat and transport water and wastewater in the manufacture the chemicals and construction materials.

Impact Assessment

9.8 As discussed in the baseline section, ambient air quality is variable across airsheds and the level of degradation in air quality is dependent on the type and intensity of economic activity undertaken within the airshed. Specific pollution sources, such as local traffic, are the primary contributors to background levels of air pollution particularly in urban conurbations.

9.9 According to the UGEE JRP all island study[94] on unconventional gas exploration and extraction activities, emissions from individual sites are usually sporadic and not unique to unconventional gas exploration activities. Air pollutant sources from unconventional oil and gas activity can include:

- point source emissions - particulate matter, CO, NOx, SOx, VOCs, methane

[94] Unconventional Gas Exploration and Extraction (UGEE) Joint Research Programme, Final Report 4: Impacts and Mitigation Measures, 2016

- fugitive emissions - methane and VOCs.

9.10 Emissions from multiple well developments in a local area or across a wider region have a potentially adverse effect on air quality by elevating ambient pollution and ozone concentrations.

9.11 For unconventional activity, effects are not expected to be significant at a national level. During stages 2 and 3, there could be locally significant air quality effects under the high activity development scenario principally relating to emissions to air from machinery, drilling and hydraulic fracturing, especially impacting sensitive receptors including residents and biodiversity (DECC, 2014). Flaring during stage 2 exploration activities could also lead to production of CO_2 and other GHGs as well as methane from flowback water. There could also be some fugitive emissions at stage 4 during decommissioning and restoration, due to gasses escaping from wells after closure, including methane emissions.

9.12 Fugitive emissions are difficult to quantify and control and potential sources include leaks from valves, wellheads and on-site accidents or accidental releases from the well casing into groundwater.

9.13 Local negative effects are temporary but could occur from the short to long term. A more significant negative effect is anticipated from unconventional oil and gas activity due to the enhanced scale of emissions, however even under the high scenario this represents a limited scale of development when compared to the scenarios used in the DECC and Scottish SEAs.

9.14 Uncertainty exists over the combination of emissions from onsite machinery, HGVs, drilling/fracturing which could lead to cumulative negative effects on sensitive receptors, with additional cumulative effects from flaring of gases in production. Locally felt cumulative effects could be significant where activities are undertaken simultaneously, or sites are located in close proximity, and where there are existing air quality issues/sensitive receptors. However, existing regulatory controls are expected to mitigate risks to a minor level.

Summary

9.15 Receptor sensitivity: Medium. In areas where air quality is already adversely affected by background factors, such as transport, an incremental increase in point and fugitive emissions will further increase the pollutant load and effectively lower ambient air quality.

9.16 Type of impact: Impact on air quality would be negative, given the relatively good background levels of air quality determinants in Northern Ireland, especially outside of urban areas.

9.17 Impact Path: The impact on air quality would be direct. The increase in particulate matter, CO, NOx, SOx, VOCs, methane is directly quantifiable and can be compared to background levels to determine the incremental increase or decrease in emissions.

9.18 Duration of impact: The impact would be medium to long-term duration, depending on the phasing, proximity and intensity of well development, the impact will persist for the duration of site activities.

9.19 Reversibility of impacts: Reversible. Once a site is decommissioned, no fugitive emissions from capped wells are expected. Air quality monitoring should be undertaken for a specified time period to confirm the absence of emissions post closure.

9.20 Significance: For the no development scenario, there would be no increase in point source and fugitive emissions over baseline conditions. For the low and medium development scenarios, the significance would be minor adverse, for the high development scenario, the significance would be moderate-adverse.

Mitigation Measures

9.21 The type and quantity of emissions generated by development for conventional and unconventional resources should be quantified in support of each development application and evaluated relative to the existing and forecast quality of the relevant airshed. Strict emissions limits can then be specified for each site to ensure that the cumulative emissions do not exceed the total pollutant load within an airshed.

9.22 Where receptors sensitive to air quality are identified and significant impacts identified, the siting of the development and number of wells should be carefully considered at the design phase so that receptors downwind are not adversely affected by emissions.

9.23 All site machinery should conform to manufacturer specifications in terms of fuel efficiency and emission limits and be maintained to always meet these specifications.

9.24 Periodic testing of air quality upwind and downwind of well sites should be undertaken and reported to the relevant authority.

Air quality impacts from construction and site traffic

Sources

9.25 Vehicle movements associated with conventional oil and gas exploration and development are mainly in relation to construction and site preparation stages.

9.26 Emissions from HGV movements and other construction and site-related traffic which, for unconventional projects, can be high-frequency at certain times of the development process.

Impact Assessment

9.27 The potential impacts of vehicle movements are mainly associated with a decrease in air quality, particularly affecting local communities in close proximity or along key transport routes. Dust is discussed in a separate section below.

9.28 The DECC and Scottish SEAs both provide evidence about vehicle movements in relation to unconventional oil and gas exploration and development, with a range of assumptions presented at different stages of the development lifecycle.

9.29 For conventional oil and gas exploration and production, during Exploration and Production Development stages, which constitutes a 14 to16 week time frame, the DECC SEA presents an assumption of 470 vehicle movements per well pad (of two wells per pad, the same as under the NI development scenarios). Applying this to the NI development scenarios suggests that there could be in the region of 940 vehicle movements under the low scenario during these activities (or approx. 9 per day over 15 weeks), 1,410 vehicle movements under the medium scenario (or approx. 13 per day over 15 weeks), or up to 2,350 vehicle movements under the high scenario (or approx. 22 vehicle movements per day over 15 weeks).

9.30 The DECC SEA report also presents assumptions for unconventional development at 820 to 2,370 vehicle movements per well during exploration drilling with coring and hydraulic fracturing. Applying this to the NI development scenarios suggests that there could be in the region of Low

4,950 to 17,600 vehicle movements per well pad (6-11 wells per pad), which is 450 to 3520 vehicle movements per well for the low scenario, to 10,290 to 36,735 vehicle movements per well pad (23 wells per pad), representing is 447 to 1597 vehicle movements per well for the high scenario. The number of vehicle movements varies depending on number of wells drilled and phasing, volume of water needed, where water is sourced, volumes of waste and wastewater generated, method if water treatment, and whether that happens offsite.

9.31 At exploration and appraisal stage, the Scottish SEA includes an assumption of 190 vehicle movements per well pad (of 10 wells) per week, over 2 years. This equates to 19,760 vehicle movements over 2 years, or 27 per day under the low development scenario, 39,520 vehicle movements over 2 years, or 54.3 per day under the central scenario, and 79,040 vehicle movements over 2 years, or 109 per day under the high scenario.

9.32 At construction stage, the Scottish SEA assumption is 7,000-11,000 vehicle movements per well pad (of 10 wells) over a 2-year construction period. The NI development scenarios assume 6 wells per pad and, applying the low-end assumption of 7,000 vehicle movements over 2 years, suggests there could be in the region of 7,000 total vehicle movements, or 9.6 vehicle movements per day under the low scenario, 14,000 total vehicle movements, or 19.2 per day under the medium scenario, or 28,000 total vehicle movements, or 38.5 per day under the high scenario.

9.33 The UGEE JRP all island study states that during exploration and site preparation activities, the number of vehicle movements would be a small proportion of those required to create emissions to cause significant environmental or health impacts. Therefore, this would be likely to represent a minor impact. Potential impacts include increase in traffic related air emissions, noise and visual impact, and potential damage to transport infrastructure, congestion, and effects on road safety. If a number of well pads are simultaneously developed in the same area, the potential of adverse effects increases due to a sustained increase in the number of HGVs in one area. The sensitivity of the receptor would be further increased if there is a single route needed for the development of a high number of pads, which could lead to a combination of increased numbers of vehicles and extension to the period of site development. This is considered to present a minor potential impact in view of the longer development period.

9.34 During end-of-project, well closure and decommissioning stages, some vehicle movements are likely to be associated with the process of reinstating original site conditions, but this is expected to be minimal and not expected to result in any adverse impacts. Following site closure, traffic movements would be limited to those associated with ongoing environmental monitoring and anticipated to be negligible.

Summary

9.35 Receptor sensitivity: Medium. The increase in pollutants generated by construction activities is limited to the construction period and is therefore short-lived. Outside of areas where air quality is already adversely affected, the incremental increase in pollutants should be within the capacity of the airshed to absorb the short-term increase and then return to prior levels.

9.36 Type of impact: Negative. Conventional, and especially unconventional, stage 2-3 activities could have locally adverse air quality effects resulting from emissions to air from HGV movements, under the high development scenario for stage 2 and under both the medium and high scenarios for stage 3.

9.37 Impact path: The impact on air quality would be a direct impact. Air quality is readily quantifiable and background levels can be used as benchmarks for short-term incremental increases to identify the capacity of the airshed to absorb an increased pollution load.

9.38 Duration of impact: Short-term for the construction process. Once the construction process is completed for conventional wells, the impact of operational and decommissioning activity is dependent on the lifetime of the well. In unconventional well development, the duration of fracking activities is dependent on the number of lateral wells drilled.

9.39 Reversibility of impacts: Reversible, after construction ceases further impacts on air quality will be limited to operational and decommissioning activities.

9.40 Significance: For the no development scenario, there would be no increase in emissions due to construction activities and site traffic over baseline conditions. For the low and medium development scenarios, the significance would be minor adverse, for the high development scenario, the significance would be moderate-adverse.

Mitigation Measures

9.41 Wells should not be sited within a specified distance to receptors sensitive to air emissions generated by construction activities.

9.42 A Construction Environmental Management Plan (CEMP) should be required for each proposed development that includes a traffic management plan to minimise emissions from vehicles utilised during construction and establish routes for construction vehicles that avoid congested areas and use of unsuitable roads.

9.43 All stationary and mobile equipment on site must comply with nationally specified energy consumption and emissions limits.

9.44 The contractor must institute a system of reporting on emissions from all stationary and mobile sources during the construction process.

9.45 Periodic monitoring of ambient air quality around well construction sites should be undertaken and reported to the relevant authority.

Dust

Sources

9.46 Sources of dust include:

- Areas that are cleared for construction, materials laydown and topsoil and other bulk materials stockpiles
- Access tracks and roads
- HGV and small vehicles travelling over unpaved surfaces at speed
- Site establishment and construction activities that impact on the cleared surfaces.

Impact Assessment

9.47 The DECC SEA identifies that there is likely to be an adverse effect locally due to dust during construction, drilling and HGV movements, associated with well pad production and site preparation.

9.48 Dust adversely affects air quality at a local level, particularly by site preparation and construction activities undertaken on surfaces that have been cleared of vegetation. Dust emissions at a project site can cause physical nuisance and impact human health, particularly people with respiratory conditions, children and older people.

9.49 Dust settling on areas downwind of construction activities smothers vegetation and can cause die-back and loss of species that are less adapted to the increased particulate matter concentrations.

Summary

9.50 Receptor sensitivity: Medium. The receptors for dust would be vegetation in areas immediately adjacent to sites and access roads that is coated by dust. Local communities and community amenities would also be receptors potentially affected by dust.

9.51 Type of impact: Dust would be a negative impact.

9.52 Impact path: The impact of dust would be direct, although limited to the area where dust increases the airborne particulate matter concentration and the area where the dust settles.

9.53 Duration of impact: The impact of dust is considered to be short-term especially where appropriate management measures are undertaken.

9.54 Reversibility of impacts: The impact of dust is reversible. Once the dust is stopped by rehabilitation of the source or a cover that prevents airborne particulate matter being generated.

9.55 Significance: For the no development scenario, there would be no increase in dust generated by activities over baseline conditions. For the low and medium scenarios, the significance would be minor adverse, for the high development scenario, the significance would be moderate-adverse.

Mitigation Measures

9.56 The Construction Environmental Management Plan (CEMP) must include measures to minimise the potential for dust generation on and around the site(s).

9.57 Periodic monitoring of particulate matter concentrations around well construction sites should be undertaken and reported to the relevant authority.

Summary table

9.58 The table below summarises the impacts associated with the air impact theme.

Table 9.1 Air Quality Assessment Summary

Potential Impact	Development scenario	Receptor Sensitivity	Type of Impact	Consequence	Likelihood	Significance
Point-source and fugitive	No development	Medium	N/A	N/A	N/A	N/A
	Low		Negative	Negligible	Likely	Minor adverse

emissions (conventional)	Medium			Negligible		Minor adverse
	High			Minor		Moderate adverse
Point-source and fugitive emissions (unconventional)	No development	Medium	N/A	N/A	N/A	N/A
	Low		Negative	Negligible	Likely	Minor adverse
	Medium			Negligible		Minor adverse
	High			Minor		Moderate adverse
Air quality impacts associated with construction and site traffic	No development	Medium	N/A	N/A	N/A	N/A
	Low		Negative	Negligible	Likely	Minor adverse
	Medium			Negligible		Minor adverse
	High			Minor		Moderate adverse
Dust	No development	Medium	N/A	N/A	N/A	N/A
	Low		Negative	Negligible	Likely	Minor adverse
	Medium			Negligible		Minor adverse
	High			Minor		Moderate adverse

9.59 The impact on air quality is generally a minor to moderate negative effect and will occur in the short term, mainly during stage 2 in a site's development cycle. Where multiple sites are located in close proximity causing an increase in related HGV movements, construction and drilling activities, the increase in pollutants will generate a more substantial adverse effect.

9.60 No substantial difference in the impact on air quality is expected by site preparation and drilling activities done for conventional and unconventional resources. However, the emissions generated at stage 3 by unconventional well operation are expected to be substantially greater than those generated by conventional well operation, due to the increased lateral wells and the potential for fugitive emissions from the lateral wells.

9.61 The no-development scenario will not adversely affect baseline ambient air quality. The impact on air quality associated with the low and medium development scenarios are assessed as minor adverse significance due to the dispersed nature of the emissions and low intensity of well development. The air quality impact associated with the high development scenario is assessed as moderate adverse due to the potential for a greater spatial concentration of the emissions and the high intensity of well development in this scenario.

10. Soils

10.1 This section covers the impact of activities on soil quality, soil sealing and erosion.

Soil quality, soil sealing and erosion

Sources

10.2 The soil condition can be affected by oil and gas developments due to land take and site development, exploration, drilling, pollution, traffic, pipelines, etc. The main potential sources are:

- The clearance of vegetation and removal of soil within the footprint of operations including the loss of soil layers
- Compaction of soils during well pad preparation and during the construction of associated infrastructure including the movement of vehicles and equipment
- Soil sealing (the loss of soil resources due to the covering of land) for well pads, access roads etc
- Storm water runoff across sites due to inadequate drainage
- Ground contamination caused by flowback fluids associated with fracturing, leaks from surface installations and saline intrusion
- Accidental ground spills and leaks.

Impact Assessment

10.3 The NI Government has produced a policy statement as part of a strategy for the protection and conservation of peatlands. The majority of peatland is in private ownership and conservation is dependent on the adoption of good management practices by landowners Outside of peatlands, soil quality is not protected but falls within protection afforded to landscapes, habitats, species and certain archaeological sites.

10.4 The UGEE JRP all island study lists potential impacts to soils during the drilling and development phase would occur as a result of the removal of vegetation, mixing of soil horizons, soil compaction, increased susceptibility of soils to wind and water erosion, contamination of soils with petroleum products, and disturbance of biological soil crusts.

10.5 The UGEE JRP all island study expects that there may be increased potential for storm water generation where high volumes and intensity of storm water runoff can result in increased erosion, which in turn results in elevated sediment loads and levels of turbidity (suspended solids) from undisturbed land.

10.6 Potential impacts on agriculture relating to UGEE activities include the temporary reduction in farmable land, the management of excavated soils, stored and replaced on site, and the potential for damage to soils that remain on site, for example through tracking by heavy machinery. Damage to soils could potentially reduce agricultural productivity if subsequently returned to agricultural use.

10.7 The DECC report and UGEE JRP all island study both observe that risks of negative effects increase commensurate with the area of land that would be required to accommodate exploration and production well pad sites and the amount of disturbance. Similarly, the impact varies depending on the sensitivity of the land. It is noted that National Planning Policies seek to avoid development in sensitive areas.

10.8 The DECC SEA cites the risk of disturbance of contaminated sites/accidental spillages to be a low secondary risk due to existing regulation and controls.

10.9 The Scottish SEA notes that for shale gas projects, controls mitigate the risk of accidental release of hazardous materials but there remains a risk of ground contamination and surface spills. There is also uncertainty over siting in areas of flood risk.

10.10 In terms of indirect impact, this may include impacts on biodiversity and natural capital, farming and agricultural livelihoods.

Summary

10.11 Receptor sensitivity: The receptor sensitivity for soils is low to medium in the context of biodiversity and agriculture in NI. However, the importance of soils and landscape for agriculture and biodiversity, would suggest a receptor sensitivity of high for the high development scenario.

10.12 Type of impact: Loss and damage to soils would be a negative impact. The loss or alienation of soil and the loss of soil condition removes tracts of land from productive use, particularly where agricultural land is lost.

10.13 Impact path: This impact could result in direct soil loss or damage, with indirect impacts on agriculture and biodiversity.

10.14 Duration of impact: Impacts could be felt in the short, medium- and long-term, the replenishment of eroded soils requires a concerted effort to ensure the replacement of soils over time and improving the soil condition also requires directed management interventions.

10.15 Reversibility of impacts: Impact of loss generally not reversible without conservation efforts. The higher the quality of the soil lost, the greater the investment required to restore the soil condition so that the land can be returned to productive use.

10.16 Significance: For the no development scenario, there would be no adverse impact on soils over baseline conditions. For the low development scenario, the significance would be negligible, for the medium development scenario the significance would be minor adverse and for the high development scenario, the significance would be moderate-adverse.

Mitigation Measures

10.17 Exploration and production activity should not be permitted within a specified distance of areas such as peatland or other areas having protected status to minimise the potential for soil loss and degradation.

10.18 A Construction Environmental Management Plan (CEMP) should include measures to minimise impacts to soil due to erosion and provide for reinstatement, as necessary.

Summary table

10.19 The table below summarises the impacts associated with the soil impact theme.

Table 10.1 Soil Impact Assessment Summary

Potential Impact	Development scenario	Receptor Sensitivity	Type of Impact	Consequence	Likelihood	Significance
Loss of soils	No development	Low	N/A	N/A	Likely	N/A
	Low		Negative	Negligible		Negligible
	Medium			Minor		Moderate adverse
	High	Medium		Moderate		Moderate adverse
Loss of soil quality or productivity	No development	Low	N/A	N/A	Unlikely	N/A
	Low		Negative	Negligible		Negligible
	Medium			Minor		Minor adverse
	High	Medium		Moderate		Moderate adverse
Impact on biodiversity or agriculture	No development	Low	N/A	N/A	Unlikely	N/A
	Low		Negative	Negligible		Negligible
	Medium			Minor		Minor adverse
	High	Medium		Moderate		Moderate adverse

10.20 In the absence of onshore oil and gas development activities under the No Development scenario, there would be no additional loss of soils or their productivity on the baseline conditions.

10.21 The impact on soils associated with the low development scenario is assessed as negligible significance due to the dispersed nature of the soil loss and limited well development. The soil loss associated with the medium development scenario is assessed as minor adverse and the soil loss associated with high development scenario is assessed as moderate adverse due to the scale of soil loss and the high intensity of well development in this scenario.

11. Water

11.1 This section covers the following topics:

- Ground and surface water abstraction
- Ground and surface water pollution.

Ground and surface water abstraction

Sources

11.2 Water sources include lakes and reservoirs, streams and rivers and groundwater (including springs).

11.3 For conventional O&G exploration and production, low volumes of water are required, but the volume required has not been quantified in the existing studies.

11.4 For unconventional developments, water demand during individual hydraulic fracturing events defines the maximum demand at any one time. The total demand is determined by the number of wells that are hydraulically fractured in the same time period.

11.5 For unconventional exploration and production, based on assumptions within the DECC SEA of 10,000-25,000 m^3 per well, taking the mid-point of 17,500 m^3 and applying this to the NI development scenarios suggests that the water abstraction volumes could be in the region of 105,000 m^3 under the low scenario, 210,000 m^3 under the average, and 315,000 m^3 under the high scenario.

11.6 The UGEE JRP all island study anticipates that the water required for unconventional projects and operations would be sourced from available water resources within or close to the licence areas in each basin. It is further expected that developers would try to source water as close as possible to individual wells pads. Precisely how and where the water would be sourced would be determined by practical considerations and cost – specifically the total costs of planning, licensing, constructing, and maintaining abstraction points versus the costs of purchase and transport of water from existing water supply schemes in the region.

Impact Assessment

11.7 Groundwater abstraction impacts include reduced baseflow to surface water bodies (if groundwater and surface water are hydraulically connected), adverse influence on the supporting conditions of nearby groundwater-dependent terrestrial ecosystems, and hydraulic interference with existing, neighbouring supply wells (public and private).

11.8 The adverse effect of water extraction is dependent on several factors including:

- the timing of the abstraction (rainy or dry season)
- cumulative effects occurring either as a result of multi well pads or several pads within a hydraulically connected area
- the availability of existing water resources and the volume of water extracted by existing users in that area
- the volume of wastewater that can be recycled and used as fracturing fluid.

11.9 The DECC SEA identifies potentially significant negative effects on water under both low and high activity scenarios for under Stages 2, 3 and 4 of the unconventional oil and gas lifecycle. Total water consumption across these stages could be between 7 and 18 million m^3 under a low scenario, and between 57 and 144 million m^3 water under high scenario. For the high scenario, this equates to an increase of 9 million m^3 annual water usage, or 18.5% of the annual mains water supplied to energy, water and waste sectors in UK; but still less than 1% of total UK annual non-domestic mains water usage. The DECC SEA assumed that there would be a 5km distance between well pad sites and activities would not be undertaken simultaneously.

11.10 The DECC SEA considers the impact on water resource availability, aquatic habitats and ecosystems and water quality to be more uncertain; but expects existing regulations would ensure mains supply or groundwater or surface water abstraction is sustainable. Use of recycling or reuse of flowback water would reduce demand. Demand reduction due to recycling or flowback water in the US is between 10-77% which, applied to high activity scenario, could lower demand to between 13 and 33 million m^3.

11.11 Both the DECC and Scottish SEAs provide evidence on the proportion of water that is likely to be returned as flowback under unconventional development activity. The DECC SEA suggests this is between 30 and 75%, and the Scottish study in the region of 25%. Applying the more conservative DECC assumption to the water abstraction volume assumptions set out above suggests that between 31,500 and 78,750 m^3 could be returned as flowback under the low development scenario, between 63,000 and 157,500 m^3 under the medium scenario, and between 94,500 and 236,250 m^3 under the high scenario.

11.12 Using the estimate for flowback water (under unconventional development activity) and assuming that a direct replacement is feasible, the potential reduction in the quantity of water abstracted for use under the low, medium and high scenarios is between 26,250 and 73,500 m^3, 52,500 and 147,000 m^3 and 78,750 and 220,500 m^3 respectively.

11.13 Flowback can be reused; however, it must be treated prior to disposal to a water body to meet water quality discharge limits. Under the high activity scenario up to 108M m^3 wastewater would require treatment, which is approximately 3% of the UK's total annual wastewater. For UOG, flowback volumes ranging from 3,000 m^3 to 18,750 m^3 per well (based on AEA report[95], 2012 - ex ante synthesis) generated from hydraulic fracturing has high levels of salinity and mineral content. Where large volumes of water require treatment, this can put pressure on existing wastewater treatment infrastructure capacity.

11.14 The UGEE JRP all island study states that abstraction pressures manifest as changes in natural and regulated water level cycles and residence times. Abstraction from rivers reduces stream flow that, in turn, alters river morphology and water quality and ultimately ecological conditions at affects stream biota. Abnormally low water levels during periods of high net abstraction represent a particular risk of impact on the shallow littoral zones, which support the populations of macrophytes and macroinvertebrates.

11.15 The UGEE JRP all island study refers to cross-border river basins where Article 3 (Coordination of administrative arrangements within river basin districts) of the EU Water Framework Directive (WFD) requires Member States to coordinate water resources management.

[95] AEA, 2012b. Climate Impact of Potential Shale Gas Production in the EU. Report for European Commission DG CLIMA, Issue 2. Available online: http://ec.europa.eu/clima/policies/eccp/docs/120815_final_report_en.pdf (accessed 29 June 2016).

Summary

11.16 Receptor sensitivity: Medium. Where excessive water extraction occurs the impact of reduced baseflow on lakes, streams and rivers, and groundwater (including springs) is only alleviated once the excessive abstraction ceases and recharge via rainfall or other increased inflow is sufficient to return the baseflow to previous flow rates and volumes.

11.17 Type of impact: Impact on water sources due to extraction would be negative for both conventional and unconventional development activity. The ecological function of aquatic ecosystems is dependent on the flow quantity and seasonal variability to provide habitat for key aquatic species.

11.18 Impact path: Direct impact on water quantity, quality and aquatic ecosystems function.

11.19 Duration of impact: Impacts are expected to be short to medium-term after abstraction ceases and resources are recharged. This assumes that the availability of water to recharge a water body is not reduced by other abstractions or a reduced rainfall season. However, given the extended operational lifecycle of unconventional development activity, the duration of the impact for unconventional activity will be longer than that for conventional development activity.

11.20 Reversibility of impacts: Impacts can be considered reversible as surface and groundwater resources are recharged.

11.21 Significance: For the no development scenario, there would be no increase in surface and groundwater abstraction over baseline conditions. Using unconventional development activity as a worse-case, the low development scenario, the significance would be negligible, whilst for the medium development scenario the significance would be moderate-adverse and for the high development scenario, the significance would be major adverse.

Mitigation Measures

11.22 Water abstractions are subject to existing control measures (systems of “prior authorisation”). In Northern Ireland, abstractions of all waters are licensed under the Water Abstraction and Impoundment (Licensing) Regulations (Northern Ireland) 2006.

11.23 The island of Ireland UGEE JRP all island study identified mitigation measures to minimise impacts of abstractions:

- reducing demand for water (by charging for water consumption and encouraging the recycling of flowback waters)
- spreading abstractions among multiple sources
- directing abstractions towards lower sections of catchments (higher order streams)
- avoiding abstractions from ecologically sensitive catchments and streams
- timing operations such that they avoid overlap between maximum demand periods and low-flow conditions.

Ground and surface water pollution

Sources

11.24 The UGEE JRP all island study identified potential impacts on water quality resulting from the following activities undertaken for conventional and unconventional development:

- storm water runoff and run-on from utility corridors, road and well pads
- surface chemical spills and leaks during transport, storage at well pads, drilling and hydraulic fracturing
- improper well construction, well completion and operation, including failures during drilling, hydraulic fracturing and production
- pit, impoundment or tank leaks of on-site stored flowback water, produced water, drilling muds and cuttings
- leaks, spills or improper disposal of flowback water, produced water, drilling muds and cuttings during off-site treatment, transport and disposal.

11.25 The UGEE JRP all island study states that quantities of drilling fluids cannot be predicted for any given site or well with certainty because this depends on drilling progress and the conditions encountered. Nonetheless, for guidance purposes, quantities can range from 0.5 to 0.6 m^3 per metre drilled and total quantities can range from 1,500 to 2,500 m^3 per well pad, depending upon depth and number of wells for conventional development and from 3,240 to 6,480 m^3 per pad for unconventional development. Thus, well depths and the number of wells drilled will determine the total quantities of waste produced at a given pad.

11.26 Drilling muds and fluids are typically stored in mud pits (impoundments) or tanks. The mud pits may or may not be lined, depending on case-specific circumstances and regulatory requirements.

11.27 Flowback and produced waters are transported through discharge pipes to storage or treatment units located on site. The fluids may be stored in on-site surface impoundments or storage tanks. The surface impoundments are typically excavated into the ground with surrounding berms or bunds and may or may not be lined. Surface impoundments may be used for temporary storage before transfer to lorries for off-site disposal or treatment or may be used as long-term storage for evaporation purposes.

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11.28 Pollution of water bodies results from uncontrolled disposal of untreated water and other liquid (chemical) wastes generated from construction, drilling and fracking activities. There is also a risk of groundwater contamination from loss of well integrity or accidental discharge where a pathway from surface to groundwater exists.

Surface Water

11.29 The island of Ireland UGEE JRP all island study states that faulty connections at pipes and leaks or ruptures in lines and failure of storage tanks containing flowback or produced waters can result in surface spills.

11.30 Surface impoundments may overflow as a result of incorrect design or unanticipated weather events. Leakage can also occur from unlined impoundments into groundwater. In some cases, a well blowout can occur, releasing fluids to the environment. However, such occurrences are rare owing to the use of blowout preventers at wells.

11.31 Produced wastes during UGEE operations include drilling fluids/cuttings and flowback and produced waters. Based on studies in the USA, approximately one-half of the recorded spills related to hydraulic fracturing activities were spills of flowback or produced waters. Typical spills are relatively small, with one-half of the spills less than 3,800 l and few exceeding 38,000 l.

11.32 The quantity of chemical additives used during hydraulic fracturing varies from 5 to 75 m^3 per well. Overall, the reported "spill rate" of chemical additives is variable, depending upon the reporting protocols and accounting methods and varies between 1.3 and 12.2 spills per 100 wells. The volume of the spills reported ranged from 19 to 72,000 l, with a median volume of 1,600 l.

11.33 The Regeneris report (2015) on UOG states that wastewater generated estimated per scenario, based on assumptions from the DECC study, represented 0.1% of UK annual wastewater and that this is not likely to have a significant effect at a national level. Possible significant effects at a regional and local scale are dependent on the location of sites relative to existing treatment infrastructure capacity. The report also noted that scrutiny through the environmental permitting system can be assumed to ensure that these effects would not be unacceptable in a local context. Also, that the scale of expansion of the industry should provide sufficient time for investment in additional capacity.

Groundwater

11.34 Fluids associated with drilling and hydraulic fracturing operations represent potential sources of contamination in the groundwater environment. Natural gas constituents that are naturally present or are released as a result of hydraulic fracturing operations are also potential sources of contamination if they migrate to the near-surface environment via natural, induced or artificial pathways.

11.35 Induced subsurface pathways result from the fractures associated with the hydraulic fracturing process intended to release gas from the target formation. The length of the induced fractures from the horizontal well may extend to several hundred metres. The propagation length of fractures must be monitored and controlled and minimum separation distances between target formations and aquifers specified. In addition, hydraulic fractures associated with one well may propagate and intersect hydraulic fractures associated with a nearby well. Therefore, the distance between hydraulic fracturing operations and wells must be controlled and minimum distances specified.

11.36 The DECC SEA considers that significant negative cumulative water pollution effects at local level are likely, indicating additional water treatment capacity required in certain localities in light of estimated volumes of wastewater.

Summary

11.37 Receptor sensitivity: High. For sensitive water bodies (surface and groundwater) the impact of a pollution event is proportional to the scale of the spill or leak, the nature of the pollutant, the effective containment of the pollution event and the remediation measures implemented. For unconventional development activity, the high development scenario has a higher potential for pollution events due to the quantities of chemicals stored onsite and used in operational activities.

11.38 Type of impact: The impact of water pollution would be negative. Water pollution has a direct impact on the quantity of water available for use and the quality of water for various use classes.

11.39 Impact path: Impact of water pollution may be direct when the pollution reaches a surface water body or indirect through soil leaching into a groundwater aquifer.

11.40 Duration of impact: The duration of impact is expected to be short-term to medium-term where the response to the pollution event is effective. However, where an indirect pollution goes undetected for some time, the impact can become long-term.

11.41 Reversibility of impacts: The impact on water is considered reversible where remediation is possible and the resources exist for effective remediation.

11.42 Significance: For the no development scenario, there would be no increase in surface and groundwater pollution over baseline conditions. Using unconventional development as a worst case, for the low development scenario the significance is minor adverse, for the medium development scenario, the significance is moderate-adverse and for the high development scenario, the significance is major adverse.

Mitigation Measures

11.43 National and local planning controls and environmental regulations should be sufficient to prevent the uncontrolled discharge of untreated waste liquids to surface water bodies or to underground wells.

11.44 Operators should be required to monitor fracture propagation and report periodically to the relevant authority to confirm that specified minimum distances from sensitive receptors are being maintained

11.45 Fluids may be treated on site for reuse, discharge or disposal off site. Tank storage is typically a closed-loop system from the wellhead to the tanks via pipes. In some cases, pipelines are used to transport flowback and produced waters off site.

11.46 No on-site storage of wastewater in unlined mudpits should be permitted; all wastewater and other fluids must be treated to specified standards as good practice, either on site or at a licenced facility

11.47 Relevant off-site facilities that can treat, recycle or otherwise dispose of on-site produced wastes are regulated landfills, treatment plants and authorised recycling facilities. However, the lack of capacity at existing wastewater treatment plants and the lack of a landfill licensed to accept hazardous waste is a serious constraint to the management of waste materials. Deep well injection of waste fluids is a further option, but it is not considered feasible in Ireland or Northern Ireland without further technical assessment, including hydrogeological characterisation of deeper bedrock formations.

Summary table

11.48 The table below summarises the impacts associated with impacts to surface and ground water bodies based on unconventional development activity as a worst-case setting.

Table 11.1 Water Impact Assessment Summary

HATCH

Potential Impact	Development scenario	Receptor Sensitivity	Type of Impact	Consequence	Likelihood	Significance
Groundwater and surface water abstraction	No development	Medium	N/A	N/A	Likely	N/A
	Low		Negative	Negligible		Minor adverse
	Medium			Moderate		Moderate adverse
	High			Major		Major adverse
Groundwater and surface water pollution	No development	High	N/A	N/A	Likely	N/A
	Low		Negative	Negligible		Minor adverse
	Medium			Moderate		Moderate adverse
	High			Major		Major adverse

11.49 In the absence of onshore oil and gas development activities under the No Development scenario, there would be no increase in water abstracted for conventional and unconventional oil and gas development activities, or in the pollution generated by conventional and unconventional oil and gas development activities, over the baseline conditions.

11.50 Using unconventional development activity as a worst-case, the impact of abstraction on water bodies associated with the low development scenario is assessed as negligible significance due to the quantity of water available in surface and groundwater bodies. The impact of abstraction associated with the medium development scenarios is assessed as moderate adverse and the significance of the high development scenario is assessed as major adverse given the quantity of water that could be abstracted. This impact is most relevant to unconventional developments which require more water.

11.51 Using unconventional development activity as a worst-case, the significance of a pollution event associated with the low development scenario is assessed as minor adverse and the significance of a pollution event associated with the medium development scenario is assessed as moderate adverse while the significance of the high development scenario is assessed as major adverse given the quantity and nature of chemical substances used during the operational stage of well development and the existing lack of capacity in wastewater treatment plants in NI.

12. Waste Management

12.1 This section covers the following topics:

- Solid waste management
- Naturally Occurring Radioactive Materials (NORM).

Solid Waste Management

Sources

12.2 Conventional and unconventional oil and gas generate a range of solid waste products including:

- Drill cuttings
- Drilling muds
- Packaging and domestic waste
- Waste oil from maintenance work on machinery
- Residues from water treatment.

12.3 Water and liquid waste disposal is discussed in section above.

Impacts

12.4 The largest quantity of waste generated by oil and gas development activities is drill cuttings. The volume generated varies between wells for conventional and unconventional resources, with the latter generating substantially greater quantities due to fracking.

12.5 Based on the DECC SEA assumption of 1,500 m^3 drill cuttings per conventional well pad (which assumes two wells per pad, as do the NI development scenarios), it is estimated that the total drill cuttings for conventional oil and gas exploration and development is anticipated to be in the region of 3,000 m^3 under the low scenario, 4,500 m^3 under the central, and 7,500 m^3 under the high scenario.

12.6 For unconventional oil and gas development, the mid-point and high-end figures from the DECC assumptions, ranging between 3,240 and 6,480 m^3 drill cuttings per well pad, have been used in this assessment. This suggests that the volume of drill cuttings for unconventional development activity could be in the region of 4,860 to 6,480 m^3 under the low scenario, 9,720 to 12,960 m^3 under the medium, and 14,580 to 19,440 m^3 under the high scenario.

12.7 Other solid waste can be hazardous (e.g., waste oil) or non-hazardous waste (e.g., wooden pallets) and is generated in much smaller quantities.

Summary

12.8 Receptor sensitivity: Low. Solid waste management is well regulated and waste management and disposal facilities are available for non-hazardous waste. However, given that there is no hazardous waste landfill in Northern Ireland, hazardous waste will either need to be exported for treatment and disposal or a suitably engineered landfill located within NI will be required.

12.9 Type of impact: Negative. Increase in quantity of waste for treatment, especially liquid waste, may be greater than existing capacity in local and regional treatment facilities and well development may outpace the incremental increase in waste treatment capacity especially over the short-term.

12.10 Impact path: Direct. Any improper handling, storage or disposal of waste has the potential to result in direct contamination of the physical environment, loss of amenity and subsequent public health issues. However, the existing system of waste management controls will serve to minimise the risk of pollution events.

12.11 Duration of impact: Medium-term. Increased capacity for waste management term will reduce pressure on existing management and treatment facilities.

12.12 Reversibility of impacts: Irreversible. Waste is generated as a direct result of activity and there is little opportunity for reuse or recycling of the main waste stream, namely drilling muds.

12.13 Significance: For the no development scenario, there would be no increase in waste materials generated over the baseline conditions. For the low and medium development scenarios, the significance is minor adverse and for the high development scenario, the significance is moderate adverse.

Mitigation measures

12.14 The capacity of existing waste management and treatment facilities should be assessed to determine where additional capacity is required.

12.15 The Construction and Operational Environmental Management Plans must include waste management measures to ensure that waste is separated, transported, treated and disposed according to regulatory requirements.

12.16 Operators must maintain a waste inventory and ensure that all waste generated is accounted for in terms of treatment and disposal.

Naturally Occurring Radioactive Materials (NORM)

Sources

12.17 Naturally Occurring Radioactive Materials (NORM) is defined as radioactive materials that occur naturally and where human activities increase the exposure of people to ionising radiation[96]. These materials normally exist at trace concentrations in rock formations. This assessment considers NORM as it occurs at well development sites.

12.18 The UGEE JRP all island study explains how NORM is concentrated and enhanced by the oil and gas recovery processes. NORM flows with the oil, gas and water mixture and accumulates inside equipment as scale and/or sludge. This enhanced NORM results from activity increasing the concentrations of radioactive substances in waste residuals (e.g. sludge, drilling mud or pipe scales), or when material is redistributed as a result of human activities or industrial processes.

[96] https://world-nuclear.org/information-library/safety-and-security/radiation-and-health/naturally-occurring-radioactive-materials-norm.aspx

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12.19 In oil and gas developments, the level of reported radioactivity can vary significantly, depending on the radioactivity of the reservoir rock and the salinity of the water co-produced from the well.

12.20 The UGEE JRP all island study specifically considered NORM in the context of the generation and disposal of contaminated flowback and produced water, where elevated levels of radionuclides (e.g. radium) have been identified, and residuals from treatment processes.

12.21 The regulations limit the disposal of NORM-containing solid waste in a municipal landfill site. Radioactivity screening is required at all municipal landfill sites and there are established limits. Above the limits, the waste would be classified as low-level radioactive waste and its disposal would be restricted to specially permitted landfill sites.

12.22 Long-lived uranium and thorium isotopes are not mobilized from the rock formations that contain them. However, Radium (Ra-226, Ra-224, Ra-228) and Lead (Pb-210) isotopes are mobilized and appear mainly in the water co-produced during oil and gas extraction. Radon-222 is the immediate decay product of radium-226 and preferentially follows gas lines. It decays to Pb-210 which builds up in gas extraction equipment. Radon has a half-life of 3.8 days[97].

12.23 NORM in the oil and gas industry poses a problem to workers particularly during maintenance, waste transport and processing, and decommissioning. External exposure due to NORM in the oil and gas industry is generally low enough not to require protective measures to ensure that workers stay beneath their annual dose limits (such as set out by the IAEA basic safety standards)[98]. The potential impact of NORM on community health and safety is discussed in Section 10.

12.24 Radon is not discussed specifically in the UGEE JRP all island study.

12.25 Environmental and community groups expressed concerns that oil and gas developments would affect existing radon levels.

Summary

12.26 Receptor sensitivity: The potential impact of NORM is limited to the disposal of water or residuals (at well sites, a centralised treatment site or permitted waste disposal site). Receptors to NORM in standard operations would be limited to workers processing and storing NORM-contaminated waste materials and equipment, and workers at waste treatment or disposal sites.

12.27 Type of impact: Negative. Exposure to NORM can have consequences for human health.

12.28 Impact path: Direct. Where site personnel are working with water or residuals where NORM is concentrated.

12.29 Duration of impact: Short-term. The half-life of radon is 3.8 days.

12.30 Reversibility of impacts: Irreversible.

12.31 Significance: For the no development scenario, there would be no increase in NORM generated by oil and gas development activities over the baseline conditions. For the low development

[97] https://world-nuclear.org/information-library/safety-and-security/radiation-and-health/naturally-occurring-radioactive-materials-norm.aspx

[98] *Ibid*

scenario, the significance is negligible and for the medium and high development scenarios, the significance is minor adverse.

Mitigation Measures

12.32 Mitigation measures to prevent NORM include monitoring levels to ensure appropriate handling and treatment, ensuring that fluid management processes are operating correctly and ensuring that NORM waste is disposed of appropriately and safely.

12.33 The International Association of Oil and Gas Producers developed a guideline document for managing NORM in the oil and gas industry (IOGP, 2008). That document lists various disposal options for NORM including land-based management, salt cavern disposal, landfilling, underground injection and offshore discharge. The feasibility of these measures in NI would require further investigation.

Summary table

12.34 The table below summarises the impacts associated with the waste management theme.

Table 12.1 Waste Management Impact Assessment Summary

Potential Impact	Development scenario	Receptor Sensitivity	Type of Impact	Consequence	Likelihood	Significance
Handling, storage and disposal of waste	No development	Low	N/A	N/A	Unlikely	N/A
	Low		Negative	Minor		Minor adverse
	Medium					
	High			Moderate		Moderate adverse
Exposure to radioactive waste materials	No development	Low	N/A	N/A	Unlikely	N/A
	Low		Negative	Negligible		Negligible
	Medium			Minor		Minor adverse
	High					

12.35 Under the No Development scenario, in the absence of onshore oil and gas development activities would be no additional impact over the baseline conditions.

12.36 The impact of waste handling associated with the low and medium development scenarios is assessed as minor adverse significance due to the low level of waste produced. The impact of waste handling associated with the high development scenario is assessed as moderate adverse due to the larger volumes of waste to be produced in this scenario.

12.37 The impact of exposure to radioactive waste materials associated with the low development scenarios is assessed as negligible significance due to the low level of waste produced. The impact of waste handling associated with the medium and high development scenarios is assessed as minor adverse.

12.38 Regulations regarding the management and disposal of waste materials and liquids containing NORM, control the level of NORM to ensure that they are correctly disposed to landfill. Industry guidelines exist to support the appropriate management of NORM in the workplace. The short half-life of Radon does not present a specific threat, however appropriate measures should be taken to ensure personnel health and safety is not compromised.

13. Climate Change

13.1 GHG emissions associated with the development and operation of wells are discussed below.

Greenhouse gas emissions

Sources

13.2 Drivers of climate change include greenhouse gas (GHG) emissions generated by:

- Land use change leading to substantial land take, particularly multi-project sites and unconventional oil and gas developments where a greater intensity of activity is expected
- Combustion of fossil fuels to meet site development and operational energy demands, including use of machinery, transportation, combustion of produced gas in flaring, to power onsite machinery, to transport equipment and materials to and from site.
- Processing and use of extracted oil and gas products. However, these downstream activities would replace existing processing and use of fossil fuels as the extracted oil and gas substitutes for imported resources.

13.3 The UGEE JRP all island study states that activities result in emissions of four principal GHGs, namely carbon dioxide (CO2), methane (CH4), nitrous oxide (N_2O) and the halocarbons (a group of gases containing fluorine, chlorine and bromine). These gases accumulate in the atmosphere, causing concentrations to increase with time (IPCC, 2007). The predominant GHGs related to unconventional oil and gas developments are carbon dioxide and methane[99].

13.4 The UGEE JRP all island study also states that the greatest contribution to emissions comes from the well completion stage, although estimates of emissions from this stage vary significantly between studies. The second most significant source at this stage is drilling and hydraulic fracturing. The emissions arise from the use of drilling equipment, transport of water and wastewater, while emissions from land clearing, site preparation and construction of the well pad, access roads and well casings, including emissions associated with transport and production of materials, are smaller.

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Land Use and Land Use Change

13.5 In terms of land use and land change, the DECC SEA assumes 3 ha per conventional well pad (which assumes two wells per pad, as do our scenarios) resulting in total land take for conventional oil and gas exploration in the region of 6 ha under the low scenario, 9 ha under the medium and 15 ha under the high scenario.

[99] Estimates of GHG emissions should include direct emissions from activities and under control of the operator (Scope 1 emissions), indirect emissions from electricity consumption supplied by another party (Scope 2 emissions) and, where data is available, all other indirect emissions occurring from sources not under control or ownership of the operator (Scope 3 emissions).

13.6 The land take assumptions for the NI scenarios are the same as in the DECC report for conventional oil and gas developments.

13.7 The impacts resulting from land take for conventional oil and gas development include CO_2 and methane emissions from vegetation and soil disturbance and associated loss of carbon sequestration capacity.

13.8 For unconventional oil and gas development, the assumptions from the DECC SEA are 3 ha per well pad, as opposed to the Scottish SEA which assumes 0.8 ha per pad. The land take assumption for the NI scenario for unconventional oil and gas development is the same as that in the DECC SEA report.

13.9 The DECC report states that UOG would result in negative effects due to pad preparation and drilling, CO_2 and methane emissions due to vegetation and soil disturbance, loss of carbon sequestration, and emissions arising from hydraulic fracturing; and the same is expected for the NI scenarios.

13.10 The UGEE JRP all island study explains that emissions arise from the energy used in the drilling of the wells and in the pumping of water and other material during hydraulic fracturing. Energy for the drilling operation (and all ancillary support activities such as well pad lighting and crew housing) is provided by large, diesel-fuelled internal combustion engines. The drilling rig engines are a source of combustion-related pollutants including carbon dioxide. This step of the process is the same for conventional and unconventional oil and gas wells. Horizontal drilling is required for shale gas and may also be used for conventional gas (and oil).

Operational Energy Consumption

13.11 In terms of emissions from activities, estimated GHGs in Stage 2 and 3 could increase by 0.96 MtCO2e p.a. under high activity scenario based on max 360 wells p.a. Stage 4 emissions could increase due to gas production, flaring and venting, and fugitive emissions, estimated to be 0.7-1.4 MtCO2e under high activity scenario, equivalent to 7.6-15.3% of 2011 levels of O&G activity in UK based on DECC (2013) figures.

13.12 The island of Ireland UGEE JRP all island study states that emissions associated with site preparation are generally small in comparison with other stages in the life cycle. GHG emissions from this stage are dominated by carbon dioxide from energy use, with some small amounts of methane and nitrous oxide emissions also arising from combustion.

13.13 The UGEE JRP all island study states that drilling is not a significant source of methane emissions. Appropriate well design and supervision, including choice and depth of casings, seals and monitoring are essential to ensure safety, avoid gas and fluid migration and maintain well integrity during the drilling phase (AEA, 2012b).

13.14 Energy for the hydraulic fracturing operation is typically provided by diesel-fuelled internal combustion engines, as for the drilling phase. However, the fracturing phase is generally over a shorter period than that required to drill the wellbore, using flatbed-mounted engines up to 1,000 HP capacity. Carbon dioxide emissions during the fracturing phase are primarily a result of fuel combustion. After completion of the first well, gas is likely to be available at the site and the use of gas engines may be possible if the quality of gas is suitable. Similarly, if a well has to be re-fractured at a later stage, then gas engines could be an alternative to diesel-fuelled engines (AEA, 2012b, as before).

13.15 The UGEE JRP all island study stated that drilling processes involve large quantities of water and sand for the proppant. Transport of the materials will be associated with GHG emissions from vehicle movements, assuming current vehicle technologies, and conventional transport fuels. The fuel consumed in the transport of the water and chemicals, and the associated emissions, is dependent on the quantities of materials that are required and the distances that the materials need to be moved and is, therefore, site specific in nature.

13.16 In addition to the emissions associated with transport, emissions may also be associated with the material used in the hydraulic fracturing process. Energy may be consumed, or process-related GHG emissions released, as part of producing the chemicals used in the hydraulic fracturing and the proppant fluid. In addition, the production of steel and cement used at the site would be associated with emissions of GHGs, having an embedded carbon dioxide content.

13.17 Upon completion of hydraulic fracturing, a combination of fracturing fluid and water is returned to the surface (flowback). Estimates of the volume of gas released during well completion vary significantly and volumes are also influenced by geology, well productivity and the well completion method. On the assumption that 90% of methane emissions released during flowback are captured and flared, this may constitute the greatest proportion of total GHG emissions resulting from well development.

13.18 After well completion, methane emissions during production and processing can come from compressors, pumps, dehydration equipment, chemical processing and incidental leaks (e.g. from pipe joints), particularly in poorly run, leaky operations. These can be reduced by maintenance of machinery and using vapour recovery units to limit venting from storage tanks.

13.19 Decommissioning procedures for gas wells have been motivated mainly by resource conservation and protection and groundwater protection (Kang, 2014[100] referenced in the UGEE JRP all island study). Therefore, the main decommissioning strategy is plugging. While there are regulations for decommissioning procedures and protocols, there is no regulation to address methane emissions from abandoned oil and gas wells and methane emissions from these wells are not included in any emissions inventories (Brandt et al., 2014 referenced in the UGEE JRP all island study [101]); the implied assumption in decommissioning regulations is that leakage will not occur. However, it is now recognised that there is potential for gas to escape following well closure due to well failure, leading to environmental risks (AMEC, 2014[102]). Gas may migrate upwards through a cracked or deformed cement sheath into the atmosphere.

13.20 Despite a growing awareness of potential fugitive emissions relating to wells following closure, data on emissions are sparse (AEA, 2012b, as before) and the result is a lack of quantification of methane emissions from these wells (Kang, 2014, as before). Problems with cement sheath failure and cement seal deterioration can mean that all wells have the potential to leak gas eventually, although it is not yet clear under what circumstances the leakage may cause substantial harm (Cherry, 2014[103]). A recent study found that methane fluxes from plugged wells

[100] Kang, M., 2014. CO2, Methane, and Brine Leakage through Subsurface Pathways: Exploring Modelling, Measurement, and Policy Options. A dissertation presented to the Faculty of Princeton University in Candidacy for the degree of Doctor of Philosophy. Available online: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC83619/lb-na-26085-en-n.pdf (accessed 29 June 2016).

[101] Brandt, A.R., Heath, G.A., Kort E.A. et al., 2014. Methane leaks from North American natural gas systems. Science 343(6172): 733–735.

[102] AMEC, 2014. Technical Support for Assessing the Need for a Risk Management Framework for Unconventional Gas Extraction. Report for European Commission DG Environment. Available online: http://ec.europa.eu/environment/integration/energy/pdf/risk_mgmt_fwk.pdf (accessed 29 June 2016).

[103] Cherry, J., 2014. Environmental Impacts of Shale Gas Extraction. GRACast Web Seminar: Series on Hydraulic Fracturing, Part 1. Groundwater Resources Association of California. Available online: https://www.grac.org/media/files/files/1c7f642e/spring2015.pdf (accessed 29 June 2016)

were not necessarily lower than methane fluxes at unplugged wells and that methane emissions from abandoned oil and gas wells appears to be a significant source of methane emissions to the atmosphere (Kang, 2014, as before).

Production and Processing

13.21 During production and processing on site, the most significant GHG emissions are from the compressors, dehydration equipment and some chemical processing (AEA, 2012b, as before). Additional GHG emissions could be fugitive methane in the form of natural gas migration away from a gas well in the event that well integrity has been compromised, especially through failure of the surface casing or the cement used to cap the well.

13.22 During transport and distribution, methane emissions due to leakage are a significant proportion of the total life cycle emissions. However, once the gas has entered the distribution pipelines, leakage rates, and therefore emissions, are the same whether the gas has been supplied from conventional or shale gas reserves.

Cumulative Impacts

13.23 Indirect effects of GHG emissions identified in the Scottish SEA report included potential effects on biodiversity. Minor negative effects were identified for shale gas due to scale of development.

13.24 The island of Ireland UGEE JRP all island study does not consider emissions and their contribution to climate change in terms of a potential interaction with habitats or species.

13.25 Other indirect effects are associated with range of activities, including development on high carbon soils, emissions embedded in sourcing of materials, and waste treatment/disposal. Land use change effects on GHG emissions at a national scale have been estimated, but the unknown location of development in relation to areas of high carbon soils introduces high levels of uncertainty.

13.26 In terms of cumulative impacts, the Scottish SEA concluded that significant negative cumulative effects would be expected for shale gas under the high scenario due to highest level of gas production, greatest number of pads and wells with impacts on land use and generating greatest impacts from transport and construction. This is likely to be lower for other scenarios.

13.27 The DECC SEA report stated that negative effects would not be nationally significant as the increase in domestic supplies would result in substitution for imported LNG with negligible effect on overall national emissions. Emissions would be less than 0.3% of current total figures.

Summary

13.28 Receptor sensitivity: Receptor sensitivity is high for climate change and national GHG emission reduction targets reflect concerns about predicted effects of climate change for NI.

13.29 Type of impact: Negative. Emissions associated with construction and operational activities and indirect from changes to biodiversity and ecosystem function due to climate change. The flaring of methane emissions may constitute the greatest proportion of total GHG emissions from well development activities.

13.30 Impact path: GHG emissions would have a direct effect on climate change via the Scope 1 and Scope 2 emissions for each well development. Indirect effects would be the result of Scope 3 emissions associated with well development.

13.31 Duration of impact: Impacts are expected to be long-term. Climate change is a long-term phenomenon and a substantial reduction in GHG emissions is national policy for NI.

13.32 Reversibility of impacts: Impacts would be irreversible if GHG emissions are not reduced.

13.33 Significance: For the no development scenario, there would be no increase in GHG emissions over the baseline conditions. For the low and medium development scenarios for conventional oil and gas well development, the significance is minor adverse. For the high development scenario for conventional oil and gas well development, the significance is moderate adverse. For the low development scenario for unconventional oil and gas well development, the significance is minor adverse. For the medium and high development scenarios for unconventional oil and gas well development, flaring of gas may result in a moderate adverse significant impact.

Mitigation Measures

13.34 The island of Ireland UGEE JRP all island study describes techniques and mitigation measures that can be used to minimise the GHG emissions. The effectiveness of these measures in reducing total GHG emissions would, however, be influenced by the relative contribution of that stage to total emissions. The types of measures identified include:

Site Preparation

- Planning for efficient rig and fracturing equipment moves from one pad to another
- Reducing transport emissions through site selection, where possible
- Ensuring that personnel, equipment, materials and services can be sourced locally
- Planning to reduce the number of vehicle journeys and use of efficient transport engines

Drilling and fracturing

- Using gas engines or engines powered from the local electricity grid
- Appropriate well design and supervision to ensure safety, avoid gas and fluid migration and maintain well integrity during the drilling phase

Production

- Using vapour recovery units for storage tanks
- Using low-bleed devices to minimise methane emissions from pneumatic devices
- Enhancing maintenance, cleaning and tuning, repairing or replacing leaking pneumatic devices
- Establishing an effective leak detection and repair programme

Well plugging and decommissioning

- Considering plugging at the planning and development stage
- Bridging, cleaning and perforation of casings to ensure effective seals (particularly across annular spaces and with the geology outside the casing)
- Using multiple plugs where required.

Summary table

13.35 The table below summarises the impacts associated with the Climate Change impact theme.

Table 13.1 Climate Change Impact Assessment Summary

Potential Impact	Development scenario	Receptor Sensitivity	Type of Impact	Consequence	Likelihood	Significance
GHG emissions (conventional)	No development	High	N/A	N/A	Likely	N/A
	Low		Negative	Minor		Minor adverse
	Medium					
	High			Moderate		Moderate adverse
GHG emissions (unconventional)	No development	High	N/A	N/A	Likely	N/A
	Low		Negative	Minor		Minor adverse
	Medium			Moderate		Moderate adverse
	High					

13.36 Under the No Development scenario, in the absence of onshore oil and gas development activities would be no additional impact over the baseline conditions. The impact of GHG emissions associated with the low and medium development scenario for conventional oil and gas well development is assessed as minor adverse significance due to the smaller scale of development, but the high development scenario is assessed as moderate adverse significance. The impact of GHG emissions associated with the medium and high development scenarios for unconventional oil and gas well development is assessed as moderate adverse due to the potential for flaring of gas. The significance of GHG emissions associated with the low development scenario for unconventional oil and gas well development is assessed as minor adverse.

14. Biodiversity, flora and fauna

14.1 This section covers the following topics:

- Habitat loss, disturbance and fragmentation
- Invasive species.

Habitat loss, disturbance and fragmentation

Sources

14.2 Habitats can be directly affected by exploration and production of conventional and unconventional oil and gas resources through the removal of vegetation, disturbance or fragmentation of habitats during site development and the construction of infrastructure. The extent of habitat disturbance depends on the number of well pads on a site and activities required for operational purposes.

14.3 Habitat disturbance can occur due to site activities including vehicle movements, operation of mechanical plant, flaring and site lighting.

Impact Assessment

14.4 The UGEE JRP all island study states that characterisation of the impacts on ecosystems and wildlife depends on the location of the well pad and its proximity to protected areas, as well as the sensitivity of the flora and fauna. The impacts on biodiversity associated with individual sites are likely to be limited to the immediate vicinity of the site. The cumulative effects of the development of multiple sites may be more widespread.

14.5 The removal of vegetation during site clearance and preparation results in habitat loss and fencing of areas and road construction may result in fragmentation of habitats. Vehicle movements may result in direct mortality of fauna species, while noise and visual disturbance cause direct and indirect impacts on faunal species at the site and in the surrounding area.

14.6 This may include the loss, reduction or disturbance of rare, endangered and endemic flora and fauna species that, in turn, adversely impacts biodiversity and ecosystem function. The loss of, or reduction in, habitat reduces the value of ecosystem services provided by a diverse ecosystem.

14.7 Habitat fragmentation where parts of a habitat are removed leaving behind smaller unconnected areas can interfere with green corridors or other linkages with direct impacts on local species, animal health, and food chains.

14.8 The UGEE JRP all island study also states that there is limited evidence for the effects of hydraulic fracturing on flora, fauna and biodiversity. The biodiversity impacts of potential concern are associated with cumulative development over a wider area and are judged to be of moderate significance.

14.9 The impact on flora, fauna and biodiversity at an individual site in the post-decommissioning phase would be comparable with many other industrial and commercial land use and is of minor significance. Over a wider area, site development could potentially result in a significant loss of natural habitat.

14.10 Pipelines constructed for use during the production phase would constitute new linear features, which could adversely affect biodiversity, particularly in sensitive ecosystems.

14.11 The Scottish SEA also considers the effects on hydro-ecological functioning due to water transportation by vehicle, surface lain or buried pipe. Damage to habitat and species quality and functionality due to accidental release of hazardous material to air, soil or water during production, storage or transportation.

14.12 The Scottish SEA expects more significant negative effects for shale gas, than for CBM, however the impacts are expected to be more temporary in duration of effect. Location of development in proximity to sites of nature conservation importance and sensitivity of the habitat loss, and proximity to sensitive receptors like designated sites and sensitive species are uncertain factors.

14.13 The DECC report considers negative secondary impacts due to construction activities and HGV movements. Negative impacts include noise, light and human presence. It is assumed that there should be 5km distance between well pad sites as a minimum. In addition, effects would be dependent on the sensitivity of receiving environments proximity and phasing of activities. Habitats regulations and planning controls are assumed to protect the conservation status of designated sites.

14.14 Noise generation during the flaring process can be minimised using appropriate flare design, and noise from the associated plant and equipment would be expected to have imperceptible effects on public health, provided that established controls used in the oil and gas industry were applied (AEA, 2012a).

Summary

14.15 Receptor sensitivity: Medium. The disturbance to flora and fauna and the associated impacts on landscapes and habitats should recover in terms of ecological function (biodiversity) with effective remediation measures post closure of the well sites.

14.16 Type of impact: Negative. Removal of habitat and the resultant loss of species diversity reduces terrestrial and potentially aquatic ecological function.

14.17 Impact path: Direct impact on flora, fauna and biodiversity.

14.18 Duration of impact: Medium-term. The estimated timeframe for well development, exploitation and closure is approximately 30 years. However, effective closure and remediation programs are required to restore ecological function and biodiversity.

14.19 Reversibility of impacts: Reversible. With appropriate habitat remediation.

14.20 Significance: For the no development scenario, there would be no increase in habitat loss, disturbance or fragmentation over the baseline conditions. For conventional and unconventional oil and gas, the low and medium development scenarios would have a negligible significance. The significance of the high development scenario for both well development types is moderate adverse.

Mitigation measures

14.21 The UGEE JRP all island study states that the development of an appropriate suite of mitigation measures would be dependent on extensive surveys of local flora and fauna to ensure the development of an appropriate suite of mitigation measures. Measures would also need to be monitored to ensure active management of the mitigation process.

14.22 Potential mitigation measures include but are not limited to:

- development of and compliance with a suitable Environmental Management Plan
- management of invasive species in accordance with best practice and the restoration of native vegetation where possible
- drilling multiple wells on well pads to minimise land take and habitat fragmentation
- avoiding protected and sensitive areas
- sensitive design of well pads, including the requirements to fit the available landscape and minimise tree removal and habitat fragmentation
- maintaining plantings of soft edges around forest clearings by maintaining existing shrub areas, planting shrubs or allowing shrub areas to grow
- limiting mowing to one cut per year or less after the construction phase of well pads is completed and prohibiting mowing during certain times, such as the nesting season for grassland bird
- designing lighting to minimise impacts through measures such as the use of low-intensity security lighting, focused task lighting, designing operating lights so that the light levels are as low as safely possible, limiting the height of lighting columns to reduce light spillage, well pad lighting to shine downwards to minimise lighting impacts on sensitive species, and the use of fitted hoods
- limiting the total area of disturbed ground, number of well pads and, especially, the linear distance of roads, where practicable
- ensuring that roads, water lines and well pads follow existing road networks and be located as close as possible to existing road networks to minimise disturbance
- gating single-purpose roads to limit human disturbance
- reinstating sites following completion as soon as practicable
- carrying out reinstatement in stages to establish vegetation and habitat incrementally as parts of the site become inactive
- using native tree, shrub, and grass species that are appropriate to the habitat
- developing a surface water protection plan, including spill response protocols
- locating hazardous substances within secondary containment, away from high-traffic areas, as far as is practical from surface waters, not in contact with soil or standing water and with the hazard labels protected from weathering
- limiting exposed and disturbed ground to prevent erosion and runoff.

Invasive species

Sources

14.23 The UGEE JRP all island study explains that invasive species can be assessed in the context of any development project and is not specific to oil and gas development.

14.24 Disruption to native ecosystems creates conditions conducive for non-native species to establish and out-compete local species for resources and habitat.

14.25 Non-native species can be transported into an area when large-scale equipment is brought in from another area without being cleaned and disinfected.

Impact Assessment

14.26 The main impacts of oil and gas developments of bringing in invasive species to NI can be loss of diversity, impacts on specific flora and fauna, food chains, or animal health.

14.27 Impacts arising from conventional versus unconventional oil and gas developments are not expected to be different, however the higher number of vehicles and increased removal of soils increase the potential for the impact to occur in the higher development scenarios.

Summary

14.28 Receptor sensitivity: Low. The sensitively of local habitats and watercourses to invasive species is dependent on the existing biodiversity and species and the active removal of invasive species. Well development in proximity to protected areas would present a higher risk from invasive species.

14.29 Type of impact: Invasive species is a negative impact.

14.30 Impact path: Invasive species would have a direct impact on native species and habitats.

14.31 Duration of impact: Duration of impact would be short to medium term, with removal of the invasive species and monitoring to ensure effective eradication.

14.32 Reversibility of impacts: The impact is reversible once invasive species are removed.

14.33 Significance: For the no development scenario, there would be no increase in invasive species over the baseline conditions. For both conventional and unconventional oil and gas, the significance is negligible for all three development scenarios.

Mitigation Measures

14.34 Measures to avoid introducing invasive species include checking equipment is clean when arriving on site. If invasive species are found procedures will be put in place to manage their removal and safe disposal.

14.35 Any protected species identified during surveys as part of the EIA or pre-construction will be identified and avoided or managed with specific mitigation measures.

Summary table

14.36 The table below summarises the impacts associated with the biodiversity, flora and fauna impact theme.

Table 14.1 Biodiversity, Flora and Fauna Impact Assessment Summary

Potential Impact	Development scenario	Receptor Sensitivity	Type of Impact	Consequence	Likelihood	Significance
Habitat loss, disturbance and fragmentation	No development	Low Medium	N/A	N/A	Likely	N/A
	Low		Negative	Negligible		Negligible
	Medium					

HATCH

	High			Minor		Moderate adverse
Invasive species	No development	Medium	N/A	N/A	Unlikely	N/A
	Low		Negative	Negligible		Negligible
	Medium					
	High					

14.37 Under the No Development scenario, in the absence of onshore oil and gas development activities, there would be no additional impacts over the baseline conditions. The loss of habitat and associated ecological function will reduce biodiversity within and surrounding the well development area. However, if development is not permitted in close proximity to protected areas, the effect will be negligible for conventional and unconventional oil and gas wells for both the low and medium development scenarios. For a high development scenario, the significance is minor adverse. While the likelihood of invasive species being introduced by well development activity is low, the potential threat to indigenous flora and fauna should be minimised and effectively managed should invasive species be discovered.

15. Cultural and archaeological heritage

15.1 This section covers the following topics:

- Loss/damage to known or unknown sites or assets
- Impacts on the settings of cultural heritage.

Loss/damage to known or unknown sites or assets

Sources

15.2 Archaeological and cultural heritage relates to elements of the environment that are valued because of their age, history, beauty or tradition. Cultural heritage includes both tangible and intangible aspects. Some may be of national or international importance, whereas others may be of importance on a local or community level.

15.3 Conventional and unconventional oil and gas developments could knowingly or unknowingly cause loss and/or damage to archaeological and historic assets as a result of land take and site development, exploration, drilling, pollution, traffic, pipelines, etc. Due to a greater number of wells per pad, and the higher requirements for water transportation associated with unconventional oil and gas development, it is anticipated that there would be more potential sources of impact associated with access roads, pipelines and vehicle movements than for conventional oil and gas projects.

15.4 The final report from UGEE JRP all island study[104] states that land take and site development associated with unconventional oil and gas development have the capacity to impact on sites of archaeological or cultural heritage, depending on site location, and these elements should be considered in the site selection. Associated linear development for access roads or pipelines also has the potential to negatively impact sites of cultural heritage or archaeological interest. These activities will require excavation of the topsoil and subsoil, and items of archaeological interest may be encountered that could be lost without specific mitigation measures put in place to prevent that.

15.5 It also identifies that changes in viewsheds or the character of the surrounding landscape have the potential to negatively impact on cultural heritage features, such as features of archaeological or architectural interest, structures and landmarks.

Impact Assessment

15.6 There is the potential for the loss and/or damage of known and unknown archaeology, and other designated and undesignated historic assets, impacting on local assets and wider cultural identity, with possible impacts on the visitor economy.

15.7 The characterisation of any impact associated with onshore oil and gas exploration and extraction activities is highly dependent on the project-level specifics of a proposal. However, the UGEE JRP all island study[105] identifies the following in relation to potential adverse impacts:

[104] Final Report 4: Impacts and Mitigation Measures, Unconventional Gas Exploration and Extraction (UGEE) Joint Research Project, 2016

[105] As above

- archaeological remains
- architectural features
- landscape and garden design
- folklore and tradition
- local battle or ambush sites
- places of pilgrimage
- holy or venerated wells
- sites of local historical or folklore importance
- established paths and trails
- language and dialect
- settlements and placenames.

15.8 It also notes that preserving the context of items of cultural heritage, especially archaeological monuments, can be just as important as preserving the remains themselves (this is dealt with in the next section).

15.9 The UK SEA does not explicitly cover cultural and archaeological heritage impacts.

15.10 The Scottish SEA deals with this impact topic for unconventional oil and gas development only. It notes that the construction of well pads and access roads can lead to loss and/or damage of known and unknown surface and subsurface archaeology and other designated or undesignated historic assets, with the potential for indirect effects arising from changes to surface draining patterns, removal of soils, flora and fauna, increased erosion, changes in the water table, etc.

15.11 Nationally significant historic environment assets are protected through legislation, and the NI planning system plays a key role in the conservation of archaeological and built heritage through historic environment advice and guidance in the planning process.

Summary

15.12 Receptor sensitivity: NI has a unique socio-environmental character that is known for its clean, green character and abundance of historic cultural assets. There are 60 conservation areas in NI and over 50,000 heritage assets are recorded of which a quarter are formally protected[106]. An associated tourism industry has developed in relation to this and consultations with community stakeholders suggest this segment of the industry is still in relative infancy in places and is closely tied to NI's natural landscapes combined with its density of cultural heritage.

15.13 The scale of loss and/or damage would be dependent on the siting of development activity and its proximity to an area with important heritage assets, as well as whether the heritage site is designated and/or known or not, and the sensitivity of the historical environment asset receptor. However, impacts on cultural heritage sites and assets would be controlled through the prevailing regulatory and planning regimes, mitigating impacts on highly sensitive receptors. This includes a theme related to archaeology and built heritage in the SPPS which specifies various controls and statutory protections related to World Heritage Sites, Areas of Significant Archaeological Interest, Conservation Areas, and Areas of Townscape Character, with the local

[106] NI Heritage Statistics, 2019

planning authority empowered to prevent development or require specific mitigation measures. Receptor sensitivity has therefore been identified as low.

15.14 Type of impact: damage and/or loss to cultural and archaeological heritage sites or assets would be a negative impact.

15.15 Type of effect: this would constitute a direct negative effect, with the potential for indirect effects caused by changes to local environmental processes further impacting on heritage sites or assets, as well as indirect or cumulative effects on the tourism industry.

15.16 Duration of impact: impacts could occur across the short-, medium- and long-term, due to the development activity lifecycle.

15.17 Reversibility of impacts: depending on the scale of damage, impacts could be reversible after development activity ceases, whereas loss of heritage assets is likely to be irreversible.

15.18 Significance: As a result of low receptor sensitivity which is protected through existing regulatory and planning controls, the consequence is expected to be negligible to minor and the likelihood is classified as unlikely, resulting in a significance level of minor adverse.

15.19 The significance level is dependent on the scale of activity, and it is anticipated that the high scenario is more likely to cause a minor adverse impact than under the medium or low scenarios, which are associated with lower levels of activity. It is also expected that impacts are more likely to be associated with unconventional oil and gas development due to a higher number of wells and the need for water transportation infrastructure.

15.20 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional impacts related to the loss or damage of cultural or archaeological heritage compared to the baseline conditions.

Mitigation Measures

15.21 The UGEE JRP all island study states that this potential impact can be mitigated through archaeological surveys, careful site selection, and recording and preserving any items or sites of archaeological interest. Any potential development should also be at a suitable distance from protected sites to ensure no negative impacts occur, or at the very least minimise negative impacts occurring as a result of development.

15.22 Detailed survey, assessment and establishment of mitigation measures at a project level may be required, given the numbers and density of sites of importance. In addition, it is important to determine the local significance of items of cultural heritage. While the determination of an appropriate suite of mitigation measures would be very dependent on project-specific details and potential impacts, it may include:

- carrying out a thorough programme of liaison with local people to establish locally important cultural heritage that may not be listed in national databases, literature or development plans
- identifying the full range of sites of archaeological and cultural heritage sites and establishing site boundaries establishing appropriate exclusion zones around sites
- avoiding potential impacts through site selection, or re-routing of pipelines or roads
- implementing a programme of archaeological works to preserve by record any items of archaeological interest encountered; should the monitoring archaeologist identify any features of interest, a strip, map and record exercise may be appropriate

- liaising with the National Monuments Service and complying with any relevant codes of practice.

Impacts on settings of cultural heritage

Sources

15.23 As outlined in the section above, the setting or context of cultural and archaeological heritage can be just as important as the remains themselves, particularly for archaeological monuments.

15.24 Projects could knowingly or unknowingly cause loss or damage to the wider setting of cultural heritage assets, including landscape, visual setting and accessibility, as a result of land take and site development, drilling rigs, pollution, access roads and traffic, pipelines, fencing, storage and processing facilities, ancillary development, etc. Unconventional oil and gas developments are anticipated to have more potential sources of impact, due to higher number of wells per pad, associated drilling and fracturing processes, and higher requirements for water transportation.

Impact Assessment

15.25 There is potential for changes to viewsheds or the character of the surrounding landscape could impact on cultural heritage features, such as features of archaeological or architectural interest, structures and landmarks, impacting on asset cultural value, recreation and amenity, and the visitor economy.

15.26 The UK SEA does not explicitly cover impacts on the settings of cultural heritage.

15.27 The Scottish SEA considers the impact of unconventional oil and gas developments, and notes they are dependent on the location of well pads and their proximity to historic assets, as well as potential cumulative effects from pads developed in close proximity. It also notes the potential for minor impacts on loss and/or damage of sites or assets to combine with direct impacts on the setting of cultural assets leading to overall loss or damage.

15.28 As outlined above, the NI planning regime acts as a control on these impacts through the planning system which plays a key role in the conservation of archaeological and built heritage, including the setting of assets. This is primarily focused on built and archaeological heritage, rather than wider dimensions of cultural heritage.

Summary

15.29 Receptor sensitivity: As identified in the section above, NI has a large number and density of recognised heritage assets which includes 60 Conservation Areas, 177 Areas of Townscape Character, and 547 Local Landscape Policy Areas, as well as close to 17,000 sites and monuments, and 400 historical nucleated settlements. This suggests that sensitive receptors across NI are protected from impacts on the setting of important cultural heritage, and receptor sensitivity has been identified as low.

15.30 Type of impact: impacts to the setting of cultural heritage would be negative.

15.31 Type of effect: a range of development activities could directly impact on cultural settings.

15.32 Duration of impact: impacts could be felt in the short-, medium- and long-term, occurring across the development lifecycle.

15.33 Reversibility of impacts: impacts would be reversible where they are related to the presence of infrastructure, equipment or traffic which is removed once the project is complete, however there is the potential for irreversible impacts as a result of impacts such as despoilment and pollution.

15.34 Significance: Due to the low sensitivity of the receptor, controlled through prevailing regulatory and planning systems, the consequence is therefore expected to be negligible to minor, and likelihood is classified as unlikely, resulting in a significance level of negligible to minor adverse.

15.35 The significance level is dependent on the scale of activity, and it is anticipated that the high scenario is more likely to cause a minor adverse impact than under the medium or low scenarios. It is also expected that impacts are more likely to be associated with unconventional oil and gas developments due to greater activity on site and the need for water and waste transportation.

15.36 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional impacts on the settings of cultural heritage compared to baseline conditions.

Mitigation Measures

15.37 Mitigation measures are closely linked to those for impacts on cultural sites or assets, as provided in the section above.

Summary table

15.38 The table below summarises the impacts associated with the cultural and archaeological heritage impact theme.

Table 15.1 Cultural and Archaeological Heritage Impact Assessment Summary

Potential Impact	Development scenario	Receptor Sensitivity	Type of Impact	Consequence	Likelihood	Significance
Loss/damage to known or unknown sites or assets	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative	Negligible to Minor	Unlikely	Negligible to Minor adverse
	Medium					
	High					
Impacts on setting of cultural heritage	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative	Negligible to Minor	Unlikely	Negligible to Minor adverse
	Medium					
	High					

15.39 Due to the low level of commercial onshore oil and gas development in the UK, there is little direct evidence about the impacts on cultural and archaeological heritage assets and their settings, and detailed assessment is highly dependent on the project-level specifics of a proposal. Impacts are expected to be more significant under the high scenario, and less significant under the medium and low scenarios, as well as potentially more significant due to fracturing processes and higher water transportation requirements associated with unconventional oil and gas developments compared to conventional development. The effects are also dependent on the siting and phasing of projects and their proximity to the receptor, with potential for cumulative impacts if developments are clustered geographically, which would be controlled through existing regulatory and planning regimes. Under the No Development scenario, there would be no additional impacts on the baseline conditions.

16. Noise and felt seismicity

16.1 This section covers the following topics:

- Noise
- Felt seismic activity.

Noise

Sources

16.2 Noise is any sound that has the potential to cause disturbance, discomfort, psychological stress, or actual physiological harm to a subject exposed to it, or physical damage to any structure exposed to it. Projects could cause noise nuisance due to exploration, construction, drilling and fracturing activities, and traffic and HGV movements.

16.3 The UGEE JRP all island study JRP notes that noise nuisance could therefore be caused during all project stages, including:

- Noise from excavation, earth moving, and plant and vehicle transport during site preparation
- Well drilling and the fracturing process itself are major sources of noise, as a result of diesel engines, air compressors, preparation and cleaning of pipes, and drill pipe connections
- Hydraulic fracturing site activities and road traffic are other potential sources.

Impact Assessment

16.4 There is potential for noise nuisance, particularly affecting local communities and settlements as well as those on key transportation routes.

16.5 The UK SEA identifies that the site preparation and construction stage of development is likely to have an adverse effect locally due to noise from construction, drilling and HGV movements. It notes that impacts would be dependent on the location of sites, the frequency, timing, and routing of HGVs, the proximity of development activities to sensitive receptors, existing levels of noise, and prevailing health issues.

16.6 The Scottish SEA identifies potential noise issues from unconventional oil and gas developments site activities and associated traffic, and also notes that there is also dependence on local factors. There is uncertainty in the available evidence about the impact of noise pollution on significant health outcomes in the short and longer term.

16.7 The UGEE JRP all island study deals with noise impacts and the potential effect on health and wellbeing. Noise can cause annoyance and disturbance to people at work or during leisure activities, as well as causing sleep disturbance and have a deleterious effect on general physical and mental well-being. It also notes that people are not equally sensitive to noise, and there is a small but significant minority who are more sensitive than others. Noise can also negatively impact sensitive wildlife.

16.8 The report addresses possible impacts at various unconventional oil and gas developments stages:

- Noise from site preparation and construction activities could affect residential amenity and wildlife, but is not expected to be any more significant than that associated with other forms of construction activity. However, impacts are dependent on local factors such as siting and phasing of activities, as well as proximity to receptors, including along the main transportation access routes.
- Noise from well drilling potentially affecting residential amenity and wildlife, particularly in sensitive areas. The levels of noise expected, when controlled, are not expected to pose risks to public health, although site operatives and visitors may need additional controls to ensure that there are no adverse effects to their health. It also notes that effective drilling noise abatement controls are well established in the oil and gas industry, and it is expected that noise controls would be applied during drilling, reducing the resultant impacts.
- Noise from the fracturing process itself relating to the pumping of proppant under high pressure and the associated pumping trucks, which operate simultaneously to inject the volume of water required to achieve the necessary pressure. The operation takes place over a period of several days for each well and would be repeated at a site for multiple wells and pads. It finds that this noise has the potential to temporarily disrupt and disturb local residents and wildlife, particularly in sensitive areas.
- Noise during production from wellhead installations is expected to be minimal, although it notes that there is no specific information available on noise levels.
- Other noise generation including during the flaring process, which can be minimised using appropriate flare design, and noise from the associated plant and equipment are expected to have imperceptible effects on public health, provided that established controls used in the oil and gas industry were applied. Noise from associated pipeline construction could affect residential amenity and wildlife, particularly in sensitive areas.
- Noise from the well completion process could arise from on-site plant and machinery, but it is likely to be lower level and of limited duration. Following project cessation, well closure and decommissioning, there would be no residual noise impacts, except for the occasional traffic arising from monitoring and maintenance.

16.9 The JRP report also notes that the magnitude of noise impacts would be dependent on proposed project details, such as the location of the sites, numbers of well pads, duration of activities such as drilling, location and types of sensitive receptors, existing noise levels, and the application of appropriate mitigation measures.

Summary

16.10 Receptor sensitivity: The UGEE JRP all island study identifies potential noise-sensitive receptors as any dwelling, house, hotel or hostel, health or educational establishment, place of worship or entertainment, or any other facility or area of high amenity that, for its proper enjoyment, requires the absence of noise at nuisance levels. Based on the well-developed noise control measures in the oil and gas industry which it is assumed would be applied to the onshore sector, and existing regulatory and planning controls for highly sensitive receptors such as protected areas, the receptor is classified as having low sensitivity.

16.11 Type of impact: Negative impacts caused by noise nuisance, likely to be more significant for unconventional oil and gas developments than conventional due to hydraulic fracturing processes and greater requirements for water transportation.

16.12 Type of effect: Direct.

16.13 Duration of impact: Noise impacts across all stages of developments, but most significant during site preparation, construction, drilling and hydraulic fracturing (for unconventional oil and gas developments), which represents a medium- to long-term time period.

16.14 Reversibility of impacts: noise impacts are reversible and will cease once project activities cease. However, there is uncertainty in the evidence about the potential long-term health impacts of noise pollution, both to humans and wildlife.

16.15 Significance: As a result of low receptor sensitivity and existing controls, both regulatory and industry, the consequence is expected to be negligible, under the low to medium scenarios, to minor under the higher scenario (this would be dependent on multiple projects being located in close proximity, particularly for unconventional oil and gas developments), and the likelihood is likely, resulting in a significance of negligible to minor adverse.

16.16 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional noise related impacts on the baseline conditions.

Mitigation Measures

16.17 Noise impacts relating to a potential development would be dependent on site location and the scale of the development. The UGEE JRP all island study notes that a full characterisation of noise impacts would be required as part of any project-level Environmental Impact Assessment and would include site surveys and noise modelling, which would in turn determine the most appropriate mitigation measures. Daytime and night-time noise levels should also be specified within any conditions associated with permission for petroleum exploration and production activities and monitored during works. Standard noise mitigation techniques such as process alterations, restriction of hours, modifying site layout and the installation of control equipment include:

- Increasing the distance between the source and the receptor – the greater the distance, the lower the noise impact, as topography and vegetation between the pad and receptor can reduce perceived noise levels
- Locating access roads as far as practical from occupied structures or sensitive receptors, serving to protect noise receptors from noise impacts associated with trucking and road construction
- Traffic noise mitigation – modification of speed limits, restricting truck traffic on certain roads, and accounting for displacement to ensure noise impacts are not shifted to another roadway
- Scheduling more significant noise generating operations during daylight hours to make them more tolerable than in evening hours

16.18 Site specific measures may also be used to mitigate noise nuisance impacts, including:

- directing noise-generating equipment away from sensitive receptors
- installing temporary sound barriers of appropriate heights between a noise-generating source and any sensitive surroundings
- using noise-reduction equipment
- limiting noisier activities to certain daytime hours

- liaising with local residents and potential receptors to provide advance notification of the drilling schedules
- scheduling drilling operations to avoid simultaneous effects of multiple rigs on the same receptors
- limiting hydraulic fracturing operations to a single well at a time
- using electric pumps.

Felt seismic activity

Sources

16.19 Unconventional oil and gas developments could lead to seismic activity being experienced locally due to hydraulic fracturing activity.

Impact Assessment

16.20 Felt seismic activity, particularly impacting local communities, can impact perceptions of safety, demand for local housing and other services, and have possible implications for the local visitor economy.

16.21 The UK SEA assessment concludes that the risk of hydraulic fracturing causing felt seismic activity (which is defined as magnitude >3) is very small, based on three referenced studies, as well as the role played by regulatory controls introduced by UK Government.

16.22 The Scottish SEA identifies a potential minor negative effect under its high scenario for shale gas development, which is reflective of hydraulic fracturing occurring over a wider area, and a lower risk under its medium and low scenarios. It also notes that the location and occurrence of potential seismic events is uncertain, based on the evidence available.

16.23 A recent British Geological Survey (BGS) report[107] on induced seismicity in relation to hydraulic fracturing in NI, provides a useful evidence base for the context of this study. The report summarises a wide range of international research including from the UK, against factors including frequency of events, proximity to the well, temporal relationship with operations, relationship with injected volume, and triggering mechanisms. It also considers geological susceptibility in NI, including the following key points:

- One of the most cited geological factors for induced seismic events is the influence of basement faults and there is considerable evidence that hydraulic fracturing operations in deeper shale intervals, close to crystalline basement are more likely to induce larger earthquakes.
- Other research suggests that fault maturity may play an important role in the observed frequency-magnitude distribution of induced earthquakes, with older, more mature (Precambrian) faults that have smoother surfaces resulting in larger slip and an increase in the ratio of larger events to smaller ones than younger, less mature (Palaeozoic) faults with rougher surfaces.

[107] British Geological Survey – Potential risks of induced seismicity from high volume hydraulic fracturing of shales in Northern Ireland, 2021

- High in-situ overpressure in shale formations, where the pore pressure is significantly above hydrostatic, has also been suggested as a controlling factor for earthquakes induced by fracturing. As a result, target formation overpressure has been interpreted as a proxy for slip potential.
- Lough Allen Basin in NI – eight wells have been drilled but in comparison to most sedimentary basins that have been explored for oil and gas, there is relatively little exploration data for the Basin, nor information about the current stress regime and whether or not faults are critically stressed. The report also notes that borehole image logs that have been run in several wells indicate the presence of open fractures in places and their orientation is consistent with a regional stress regime dominated by NW-SE compression similar to that found elsewhere in the UK.
- Rathlin Basin – geological mapping of the surface bedrock gives very little indication of the nature of the geological structure within the basin. The Ballinlea No. 1 well is the only modern oil and gas exploration well in the basin, and the drilled sequence was found to be normally pressured. There is little exploration geophysics data for the Rathlin Basin and data quality is poor. As a result, the detailed structure within the basin is poorly known.

16.24 The report also considers the historical seismicity of NI, as well as more recent instrumental data:

- An academic review[108] of published data confirms that earthquake activity is very low. Historical accounts reveal only 26 events in the period 1500 to 1970, which can be deemed credible. Half of these accounts can be attributed to earthquakes that occurred outside Ireland, in England, Scotland or Wales, where there is substantial evidence of widely felt and occasionally damaging earthquakes stretching back many hundreds of years. These were nearly all events of around magnitude 5 ML or above that occurred in the western part of Britain and were widely felt across Britain and Ireland. The other thirteen events occurred in Ireland and the immediate offshore area. All of these have low intensities suggesting that these were small earthquakes. Nearly all the historical activity is concentrated around the coast and there is an almost complete absence of seismicity inland.
- Instrumental data from the Dublin Institute of Advanced Studies (DIAS) and the British Geological Survey (BGS) catalogues also confirm these low rates of seismic activity. Almost all the instrumental seismicity lies in areas where historical earthquakes have occurred; mainly in Wicklow and the Irish Sea; Wexford, Waterford and Cork on the south coast of Ireland and, Donegal in the north. The exception to this is the magnitude 4.0 ML earthquake off the coast of Mayo in 2012, which is the largest Irish event in the catalogue. Nearly all the seismic activity in Ireland, both instrumental and historical is concentrated around the coast and there is an almost complete absence of seismicity inland, with only two instrumentally recorded earthquakes in County Leitrim.
- Baptie et al. (2016) used the combined historical and instrumental catalogue to determine an earthquake activity rate for Ireland, which suggests an earthquake with a magnitude of 4 Mw or greater approximately every 476 years. This contrasts with a rate for the UK of a magnitude 4 Mw earthquake every six years. However, the results strongly

[108] Baptie, B., et al. (2016) Final Report 2: Baseline Characterisation of Seismicity. Joint Research Programme on the Environmental Impacts of Unconventional Gas Exploration and Extraction, Environmental Protection Agency, Ireland. ISBN: 978-1-84095-688-7. [Available at https://www.epa.ie/pubs/reports/research/ugeejointresearchprogramme/].

depended on assumptions of catalogue completeness, which highlights the problem of estimating reliable rates in low seismicity regions, where data are sparse.

16.25 The report addresses the assessment of hazard and risk associated with induced seismicity:

- Hazard is a function of the frequency of earthquakes in space and size. However, for new hydraulic fracturing there is no data available to develop such assessment models. Induced seismicity also has a strong dependence on both the locus and nature of operations, meaning the hazard will be time dependent and increase with factors such as the number of wells.
- Risk is a function of both exposure and vulnerability, e.g. the number of buildings exposed to shaking and the susceptibility of those buildings to damage, as well as the hazard. Therefore, risk is higher in a densely populated area, even if the hazard is comparable.
- Again, there is a general lack of data available to enable the development of models to assess hazard and risk effectively for induced seismicity, including for defining potential maximum magnitude or damage potential, and the study notes that there are relatively few risk assessments for hydraulic fracturing operations published, and even fewer that quantify risk in terms of damage or loss.

16.26 The UGEE JRP all island study does not deal with induced seismicity explicitly, although it is referenced in the section on human health impacts. This corresponds with a lack of available evidence about the impact of induced seismic events on people, including their physical health and safety, as well as less tangible impacts on mental wellbeing, anxiety and stress. The report does include a detailed account of monitoring and mitigation activities associated with seismicity.

16.27 It should be noted that the moratorium on hydraulic fracturing in England was largely due to the occurrence of felt seismicity and concerns about the ability to mitigate these impacts effectively.

Summary

16.28 Receptor sensitivity: based on gaps in the available evidence about potential induced seismicity, the receptor has been classified as medium.

16.29 Type of impact: Negative.

16.30 Type of effect: Direct effects of induced seismicity due to hydraulic fracturing activities under unconventional oil and gas developments only.

16.31 Duration of impact: Short-term impacts felt during hydraulic fracturing stage.

16.32 Reversibility of impacts: impacts are reversible, unless damage or loss is severe enough to be irreversible, including potential for serious injury or death.

16.33 Significance: As noted above, there is no available evidence, or established models, to be able to assess hazard and risk effectively. However, it is expected that potential impacts are more likely and could be more significant under the high scenario, particularly if multiple unconventional oil and gas developments are sited close together, which would constitute a higher number of wells across a wider area with potential for cumulative impacts. Therefore, the consequence could range from negligible to moderate, as a result of the existing aspects of uncertainty around felt seismic occurrences, and the likelihood is unlikely to likely, resulting in a significance level of negligible to moderate adverse. There could be potential for transboundary impacts dependent on the siting and clustering of development sites although there is uncertainty in the evidence base in terms of estimating the potential scale and reach of felt seismic events.

16.34 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional felt seismicity impacts on the baseline conditions.

Mitigation Measures

16.35 The BGS report identifies the following developments in mitigating the induced seismicity impacts of hydraulic fracturing operations:

- The UK Department for Energy and Climate Change (DECC, 2013) published a regulatory roadmap that outlines regulations for onshore oil and gas (shale gas) exploration in the UK. These regulations contain specific measures for the mitigation of induced seismicity including: avoiding faults during hydraulic fracturing; assessing baseline levels of earthquake activity; monitoring seismic activity during and after fracturing; and, using a 'traffic light' system that controls whether injection can proceed or not, based on that seismic activity.
- However, identification of faults in the locus of operations is challenging, even where 3-D reflection seismic data are available, and basins such as the Bowland Shale have been subject to multiple episodes of deformation, resulting in structural complexity that makes data difficult to interpret. Even where faults can be identified it is difficult to tell if they might be seismogenic.
- Traffic light systems are a widely implemented means of mitigating the risk of induced seismicity during hydraulic fracturing operations themselves. These are essentially control systems for management of induced seismicity that allow for low levels of seismicity but are intended to reduce the probability of larger events that may result in a concern for public health and safety by limiting/stopping operations at certain thresholds. These thresholds are generally based on levels of ground motion which may represent a hazard or a public nuisance. In the UK, the magnitude limit of 0.5 M_L for the cessation of operations is considerably less than those limits applied elsewhere internationally, however, the red-light threshold in the UK only requires a temporary suspension of operations, as opposed to a complete cessation of operations at the well pad. Despite their widespread implementation, traffic light systems have often failed to preclude larger earthquakes. These shortcomings have led to suggested modifications to traffic light systems to improve performance (please refer to the BGS Report, p.20).

Summary table

16.36 The table below summarises the impacts associated with the population impact theme.

Table 16.1 Noise and Seismicity Assessment Summary

Potential Impact	Development scenario	Receptor Sensitivity	Type of Impact	Consequence	Likelihood	Significance
Noise	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative	Negligible	Likely	Negligible
	Medium					

HATCH

	High			Minor (dependent on siting of multiple projects)		Minor adverse
Felt seismic activity	No development	Medium (unconventional oil & gas devt only)	N/A	N/A	N/A	N/A
	Low		Negative	Negligible to moderate	Unlikely to Likely	Negligible to Moderate adverse
	Medium					
	High					

16.37 Due to the uncertainty in the available evidence and inability to assess hazard and risk effectively, the significance for felt seismicity ranges from negligible to moderate adverse. Both noise and felt seismicity-related impacts are expected to be more significant under the high scenario, and less significant under the medium and low scenarios, as well as more significant due to unconventional oil and gas developments compared to conventional developments. The effects are also dependent on the siting and phasing of projects, and their proximity to the receptor, and would be controlled through existing regulatory and planning regimes. Under the No Development scenario, there would be no additional impacts on the baseline conditions.

17. Health

17.1 This section covers the following topics:

- Health and safety, both for occupational workers and public safety
- Public health and wellbeing
- Amenity, recreation and physical activity
- Social cohesion and community wellbeing.

Health and safety

Sources

17.2 Immediate physical health and safety concerns for the project site and associated workforce, and public safety associated with site security and transportation to and from the site, road traffic accidents and accidental spillages.

Impact Assessment

17.3 The impact assessment considers the Health and safety impacts for site workers and operatives, public safety impacts for local residents and visitors to the local area, and public health impacts for the wider local community, particularly impacting on those in close proximity to project sites or local transportation routes and particularly sensitive receptors.

17.4 Public safety impacts associated with transportation and site traffic, leading to increased road traffic accidents are not directly covered in the UK SEA. The Scottish SEA identifies a potentially negative effect related to unconventional oil and gas developments, based on the effect of increased traffic movements and the impact on road accident risk. It also notes that impacts are dependent on the location of developments and their proximity to each other and to receptors, with potential for cumulative effects on road safety.

17.5 The UGEE JRP all island study addresses traffic safety impacts at each stage of development for unconventional oil and gas developments:

- Site preparation: number of vehicle movements is fairly low, although potential impacts are noted to include road safety during the period of site preparation. The most sensitive situation is likely to be a route located through a town centre leading to a shale gas development area. A single route could plausibly be needed for the development of a large number of well pads, depending on the scale of development proposed. This could result in a combination of increased numbers of vehicles, or an extension of the period of site development to several years. This is considered to be likely to present a minor potential impact in view of the longer development period.
- Well construction, hydraulic fracturing and well completion: the impacts from traffic associated with an individual site were estimated to be likely to be "minor" in view of the short duration, although it would potentially be noticeable by local residents. However, the impact of traffic associated with more widespread development, including the risks posed by traffic accidents, may be of moderate significance.

- Project closure and decommissioning stage: some truck movements may be associated with the process of reinstating original site conditions but likely to be minimal and not expected to pose significant impacts, representing low threat of road traffic accidents.

17.6 The report also notes that classifying the magnitude of impacts would depend on the details of individual project proposals.

17.7 Additionally, environmental and community groups observe that historically spending on road infrastructure in NI has been relatively low and cite poor road conditions as a factor in accident risk.

Summary

17.8 Receptor sensitivity: the receptor is classified as low, being represented by the occupational workforce and local residents in terms of road safety. In reality, the sensitivity of the receptor is dependent on individual project proposals, including factors such as scale of activity, siting and phasing and proximity, as well as the existing regulatory regime and planning controls.

17.9 Type of impact: impacts on health and safety would be negative.

17.10 Type of effect: direct health impacts as a result of site operations, associated vehicle movements and traffic.

17.11 Duration of impact: Short to long-term, as health and safety impacts could occur across the development process as well as post-closure.

17.12 Reversibility of impacts: some impacts would be reversible, for example, respiratory conditions would improve once operations ceased, however there is potential for other health impacts to be irreversible including serious health conditions, injuries and death.

17.13 Significance: the existing research suggests that under prevailing regulatory and planning regimes, operations would be undertaken to a high standard and potential health and safety impacts would be minimised. At the same time, there is considerable concern within the general public in NI about such development, particularly unconventional oil and gas development. Therefore, the consequence is anticipated to range from negligible to minor, based on the low to high development scenarios and the potential for cumulative health and safety, including road safety impacts, dependent on the location and potential for clustering of projects. The likelihood is unlikely, based on existing regulatory controls, and this results in a significance of negligible to minor adverse.

17.14 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional health and safety impacts on the baseline conditions.

Mitigation Measures

17.15 As discussed above, the prevailing regulatory and planning regimes represent a major part of effective mitigation, and the Scottish SEA notes avoiding areas with a high density of sensitive receptors would mitigate impacts, and the use of contingency planning to deal with the impacts of unexpected events and hazards to reduce potential physical health and safety risks.

17.16 The UGEE JRP all island study notes the requirement for a transport and traffic management plan as part of any permit application and identifies the following mitigation measures for road safety impacts, including:

- route selection to maximise efficient driving and public safety
- road safety assessment and, following agreement, implementation of safety measures such as signage and increasing sight distances
- avoiding peak traffic hours, school drop-off and pick-up hours in the vicinity of schools and community events and implementing overnight quiet periods
- advance public notice of any necessary detours or road closures
- adequate off-road parking and delivery areas at the site to avoid lane or road blockage
- providing frequent passing places (turnouts) on narrow roads
- limiting truck weight, axle loading and weight
- specifying that the operator would pay for the addition of traffic control devices or trained traffic control agents where required.

Public health and wellbeing

Sources

17.17 Public health and wellbeing impacts associated with air quality, dust and odour, ground and surface water pollution, waste, NORM, noise, light, felt seismicity and other environmental impacts.

Impact Assessment

17.18 The evidence on public health impacts in a UK context focuses on unconventional oil and gas development.

17.19 Potential public health and wellbeing impacts for local residents and communities are addressed in MedAct's 2015 report[109] on unconventional oil and gas development at a UK level, which identifies the following risks to public health:

- Air Pollution: respiratory disease, carcinogens, birth defects, chronic respiratory disease
- Contamination of ground and surface water: drinking water
- Traffic, dust, noise, odours, un-natural light and other nuisances: traffic fatalities, health hazards, stress, stress as a co-factor.

17.20 MedAct's updated public health assessment report in 2016 on shale gas production in England identifies the following direct, or immediate health issues:

- Risk of adverse reproductive outcomes due to exposure to endocrine disrupting chemicals which can be potent even at relatively low levels
- Risk of respiratory effects resulting from ozone and smog formation, which may affect communities living at a distance from oil and gas extraction sites
- Stress, anxiety, mistrust, fear and other psycho-emotional effects arising from nuisance impacts, as well as actual and perceived social and economic disruption.

[109] https://www.medact.org/wp-content/uploads/2015/04/medact_fracking-report_WEB4.pdf

17.21 The report also finds that the cumulative and synergistic risks of chemical, physical and psychosocial stressors of multiple well pads and boreholes across a relatively densely populated and economically active, rural landscape would pose a health and environmental threat, particularly if regulation is inadequate and if tight profit margins cause companies to take shortcuts and minimise costs. It notes that it is important to recognise the uncertainty about the degree of risk and not to exaggerate the threat posed by shale gas production. Society presently tolerates a number of industrial and commercial practices that are considerably more harmful to human health and the environment. However, the MedAct report concludes that unconventional oil and gas developments would produce risks and some harms. It is therefore important that the risks are well understood and that regulation and subsequent monitoring is able to keep the level of risk to an acceptable level, and that the benefits of development outweigh the harms. This is particularly important for local communities who will bear the brunt of the immediate risks and harms associated with unconventional oil and gas developments.

17.22 Public Health England (Kibble et al, 2014[110]) reviewed the potential public health impact of direct emissions of chemicals and radioactive material (NORM) from the extraction of shale gas. The report concludes that the potential risks to public health from exposure to the emissions associated with shale gas extraction will be low if the operations are properly run and regulated. Most evidence suggests that contamination of groundwater, if it occurs, is most likely to be caused by leakage through the vertical borehole. Contamination of groundwater from the underground hydraulic fracturing process itself (i.e. the fracturing of the shale) is unlikely. However, surface spills of hydraulic fracturing fluids or wastewater may affect groundwater, and emissions to air also have the potential to impact on health.

17.23 The UK SEA finds that if properly run and regulated, there are low risks to public health, based on extrapolating evidence from overseas. It does note possible secondary negative effects on human health from contamination of groundwater or surface water if consumed, but regulatory requirements should mean this risk is very low, and pollution control measures with relevant regulatory controls would help mitigate this risk further.

17.24 The Scottish SEA identifies a range of potential health impacts from unconventional oil and gas developments including:

- Increased risk of road accidents
- Accidental release of hazardous materials
- Explosive risk including waterborne methane
- Occupational risks associated with respirable crystalline silica.

17.25 It identifies a potentially significant negative effect reflecting the physical health risks, and potential impacts dependent on waterborne methane posing a potential explosive risk and the extent to which crystalline silica could pose a risk to the health of nearby residents. It also finds that there could be significant negative cumulative effects based on a range of impacts on health and wellbeing and dependent on the scale of activity. The greater the scale of activity, the more that cumulative impacts are likely, depending on the siting and phasing of sites, their proximity to each other and to local receptors.

17.26 The UGEE JRP all island study notes that gas emissions are cited by the public to be of concern from a human health viewpoint. Whilst these can be adequately managed during operations,

[110] Kibble, A. et al (2014). *Review of the Potential Public Health Impact of Exposures to Chemical and Radioactive Pollutants as a Result of the Shale Gas Extraction Process*. Centre for Radiation, Chemical and Environmental Hazards, January 2014, Public Health England.

following closure of a well, there is evidence that sealed and capped wells can deteriorate with time and stray gas leaks can occur. However, the study also notes that neither the reasons for this nor the scale of the emissions is quantitatively known and so the impact cannot be reliably assessed until further data is available.

17.27 Environmental and community groups commented on a baseline of high levels of mental health issues in NI compared to other parts of the UK linked to other health and economic factors and the legacy of conflict in NI.

17.28 Stakeholder engagement with environmental and community groups highlighted the considerable concern about the health impacts of oil and gas development, particularly for unconventional oil and gas developments, both in the short-term as well as the poor evidence about the long-term health implications for future generations. Stakeholders also highlighted more strategic concerns about the capability of existing environmental regulation in NI to be able to ensure these activities are properly regulated and controlled.

17.29 This assessment is based on published evidence in the UK, which in turn is based on studies of operations in other geographies. There is a limit to how evidence from elsewhere can be applied in the NI context, and it is important to recognize that the evidence base itself has already been recycled from studies in North America and elsewhere. In reality, these issues are area specific. The report[111] that was produced as a result of the consultation undertaken on unconventional petroleum extraction in Wales sets out this limitation clearly:

- Petroleum extraction is a mature industry, but unconventional extraction methods are relatively new and there is a lack of operational experience in the UK. This means that there is no evidence on the potential impacts of unconventional oil and gas at a local site by site basis. The majority of the available research evidence and data on petroleum extraction originates from countries outside the UK which already have commercial scale operations, especially in the United States.
- Caution is recommended when extrapolating evidence from other countries since the data used is country-specific and the mode of operation, underlying geology, local site specific factors, local socio-political demographics and the regulatory regime are likely to be very different.
- A number of UK reports (including those from Public Health England, the Independent Expert Scientific Panel for Scottish Government and the Royal Society) note that the technology and regulatory framework exists to allow for safe extraction of petroleum reserves. Both Public Health England and the Independent Expert Scientific Panel for Scottish Government concluded that the potential risks to public health from exposure to the emissions associated with unconventional gas extraction should be low if the operations are properly run and regulated.
- The Welsh consultation report broadly supports this view, based on appropriate mitigation and control measures being put in place to ensure that the regulatory framework identifies and manages all potential hazards from unconventional oil and gas. Similar approaches are used to effectively regulate other industries such as incinerators, landfills, waste transfer sites which have the potential to pollute the environment.
- However, it is important to recognise that gaps in the evidence base do exist and more knowledge is needed to better understand the technology to minimise risk and how

[111] https://gov.wales/sites/default/files/consultations/2018-06/180703-petroleum-extraction-policy-in-wales.pdf

current regulations can best be applied. The Welsh report recommended a more detailed Wales specific review to better understand the environmental and wider health implications of petroleum production.

17.30 As a result, whilst the evidence available suggests that major health impacts are not expected, except for more sensitive receptors factors such as social perceptions, anxiety and mental wellbeing, this cannot be definitively answered without further research. It is also important to note that there is a lack of long-term evidence about effects beyond post-closure, as well as cumulative or transboundary effects for either physical or mental health and wellbeing.

17.31 There is therefore a lack of evidence to draw definitive conclusions about potential impacts on public health and wellbeing, and more detailed research is required.

Summary

17.32 Receptor sensitivity: the receptor is classified as medium, based on the wide number of public health and wellbeing impacts that could affect a variety of different receptors. In reality, the sensitivity of the receptor is dependent on individual project proposals, including factors such as scale of activity, siting and phasing and proximity, as well as the existing regulatory regime and planning controls.

17.33 Type of impact: impacts on public health would be negative.

17.34 Type of effect: direct health impacts as a result of site operations, and potential indirect effects as a result of environmental processes resulting in impacts reaching other areas, including potential for transboundary effects.

17.35 Duration of impact: short- to long-term, as health impacts could occur across the development process as well as post-closure and into the future. Existing evidence is not clear on long-term implications.

17.36 Reversibility of impacts: some impacts would be reversible, for example, respiratory conditions would improve once air quality impacts ceased, however there is potential for other health impacts to be irreversible including serious health conditions, injuries and death.

17.37 Significance: there is a lack of primary evidence in the UK for the health impacts of onshore oil and gas development, however, the existing research suggests that under prevailing regulatory and planning regimes, operations would be undertaken to a high standard and potential health impacts would be minimised. At the same time, there is considerable concern within the general public in NI about such development, particularly unconventional oil and gas development. Therefore, the consequence is anticipated to be negligible for conventional oil and gas development, due to the established nature of the activities, and range from negligible to moderate for unconventional oil and gas development, based on the difference in the low to high development scenarios as well as uncertainties due to the lack of existing evidence in the UK and the potential for a range of public health and wellbeing impacts. The likelihood is assessed as unlikely, based on existing regulatory controls, and this results in a significance of negligible to moderate adverse (although this is subject to the aspect of uncertainty and gaps in evidence cited above). There is potential for cumulative impacts dependent on the siting of multiple development sites, as well as transboundary effects where developments could generate impacts that reach communities in the ROI.

17.38 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional public health impacts on the baseline conditions.

Mitigation measures

17.39 As noted in the Health and safety section above, the UGEE JRP all island study outlines mitigation measures for road safety impacts.

17.40 The mitigation measures associated with environmental impacts that are linked to public health are included in the relevant sections above: air quality, water, soils, waste, NORM, etc.

Amenity, recreation and physical activity

Sources

17.41 Projects could lead to a decrease in physical activity, recreation and amenity activities, due to nuisance, environmental contamination and pollution effects preventing physical and leisure activities outdoors, outdoor visitor economy, etc.

17.42 The following topics relating to oil and gas development represent potential impactors on human amenity, recreation and health:

- Noise and odour nuisance
- Air quality and dust
- Water (surface and groundwater)
- NORM
- Vibrations and felt seismicity
- Community facilities
- Physical activity and recreational activities
- Perception effects.

17.43 As the topics above suggest, health impacts associated with a loss of amenity and recreation are not solely about physical changes to land use or accessibility, or environmental impacts. Perception effects also play a significant role, and can result in concerns, anxiety and potential mental health impacts due to perceived risks to physical health.

Impact Assessment

17.44 There is potential for a decrease in healthy living and physical activity, potentially impacting on quality of life, particularly impacting people local to the project site.

17.45 The UK SEA identifies a potential negative effect on quality of life depending on the location and proximity of local populations, due to noise, vibration and air quality, and associated HGV movements. This could be significant for communities close to sites, or living/working adjacent to minor roads during well construction, drilling, and particularly during hydraulic fracturing on unconventional oil and gas developments. The effects are local but under a higher scale of development, this could become significant due to the magnitude of effect if concentrated at a local/sub-regional level. It also notes that this could also give rise to locally significant negative cumulative effects on quality of life but planning controls and other regulatory requirements should mitigate this. Impacts are also dependent on local factors including the location of sites, frequency, timing, routing of HGVs, proximity to sensitive receptors, existing levels of nuisance, and prevailing health issues, etc.

17.46 The Scottish SEA finds potential impacts from unconventional oil and gas developments on local amenity and mental wellbeing, and access to opportunities for recreation and physical activity, as a result of impacts relating to wider environmental quality such as landscape, amenity and access to recreational resources and the direct and indirect effects on health and wellbeing as a result. Whilst impacts are dependent on the location of pads and potential impacts on recreational resources, the assessment identifies a potential minor negative effect reflecting loss of land for access and recreation, as well as impacts on environmental quality. It also notes the potential for significant negative cumulative effects based on a range of impacts on health and wellbeing under its high development scenario.

17.47 The UGEE JRP all island study confirms that in the event that any potential unconventional oil and gas developments are located adjacent to existing playgrounds or sporting facilities such as pitches, which residents may use for exercise and as part of a healthy lifestyle, there may be a reduction in these activities. An increase in traffic may also deter residents from cycling or walking the roads surrounding the site. Appropriate site location and development can be used to mitigate these potential impacts.

17.48 It also discusses that the impacts of a development on health and wellbeing can be related to both the physical emissions of an activity, such as emissions to air or water, but also to the perceptions people have of a development. Risk perception of environmental hazards can cause anxiety, which has a negative impact on public health that is related to how people believe they may be affected by it rather than the likelihood of their exposure to it. The report summarises relevant research into commonly raised concerns about oil and gas development activity:

- emissions to air and airborne contaminants
- emissions to water and waterborne contaminants
- exposure to radioactive materials
- exposure to flammable gases
- exposure to potentially hazardous materials
- risks from induced seismicity
- road safety and traffic concerns
- potential impacts on domestic and farm animal health and fish

17.49 Impacts on amenity, recreation and opportunity for physical activity are localised and therefore dependent on factors such as the location, and phasing of sites, their proximity to sensitive receptors, such as recreational spaces and local residents, as well as the scale of proposed activity. Unconventional oil and gas developments are expected to have greater impacts on quality of life, due to direct effects as well as community perceptions of these projects leading to higher levels of concern and anxiety and further impacting on healthy lifestyles.

Summary

17.50 Receptor sensitivity: the rurality of the NI context enhances the sensitivity of this receptor, however local planning system will control the location of projects. At the same time, there are high levels of public concern around oil and gas development, particularly unconventional oil and gas development. Based on the scale of activity within all of the development scenarios, its sensitivity is classified as low.

17.51 Type of impact: impacts on amenity, recreation and physical activity would be negative.

17.52 Type of effect: direct impacts as a result of site activities and emissions to air and water, as well as potential indirect impacts due to social perceptions and concerns leading to further reductions in quality of life.

17.53 Duration of impact: short- to long-term as impacts can occur across all stages of development.

17.54 Reversibility of impacts: impacts are reversible once development activity ceases and sites are restored to their former condition.

17.55 Significance: unconventional oil and gas developments are expected to have a greater impact on quality of life due to the impact of hydraulic fracturing processes, as well as higher levels of societal concerns and anxiety. However, these impacts are localised and dependent on factors like the scale and location of development as well as proximity to receptors, which would be controlled under the existing planning regime. Therefore, the consequence is expected to be negligible to minor and likelihood unlikely to likely, resulting in a significance level of negligible to moderate adverse.

17.56 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional amenity, recreation and physical activity impacts on the baseline conditions.

Mitigation Measures

17.57 The Scottish SEA identifies some high-level recommendations to mitigate impacts on local amenity and mental well-being, including the screening of site activities through planting to help to reduce impacts on local amenity associated with unconventional oil and gas developments.

17.58 According to the UGEE JRP all island study, local and regional planning documents are important in defining and protecting the character of a local area and are the principal way of managing and guiding positive change and mitigating potential negative impacts. Care should be taken during site selection to avoid any sites with potential impacts on community amenities such as walking and cycling routes, playing fields and recreational areas.

17.59 However, it also notes the importance of effective communication and proactive engagement to address concerns and reduce mental wellbeing impacts, including the following key points:

- Good communication and public involvement from an early stage is essential for generating trust. Distrust of authorities is commonly reported in the context of potential environmental impacts of proposed developments.
- Distrust may be an indicator of a lack of common understanding, and debates by professionals about whether or not public concerns were justified, or whether or not any hazard actually existed, and the magnitude thereof, can indicate a lack of understanding of the effect of anxiety on public well-being.
- Effective risk communication is not simply a one-way flow from sources of information about the risks posed by environmental hazards to health (scientists, agencies, interest groups, eyewitnesses) through transmitters who amplify the message (media, institutions, interest groups, opinion leaders) to receivers who accept the information (general public, affected people, group members, those exposed), but a two-way exchange, or even dialogue, between all parties.

- To address concerns, thereby reducing potential health impacts relating to anxiety over impacts, a programme of public engagement, information and consultation should be undertaken involving true two-way communication.

17.60 The JRP report also notes that public reactions to risk often have a rationale of their own and that "expert" and "lay" perspectives should inform each other as part of a necessary two-way process. This process should include:

- information campaigns
- adequate and appropriate (two-way) communication activities
- providing evidence on known risks
- making sure that information provided is accurate, consistent and provided in clear non-technical language
- ongoing programmes to monitor environmental factors that may be perceived to be a health risk.

Social cohesion and community wellbeing

Sources

17.61 Projects could lead to high levels of in-migration of skilled labour supply to the site, which could lead to damage to social cohesion, or dilution of culture and language. The UGEE JRP all island study notes that should a proposed development result in a relatively large influx of workers in comparison with the local population, this may have an adverse impact on the cultural heritage of a community, such as local traditions.

17.62 Projects, particularly activities related to unconventional oil and gas development, could also lead to concerns within the resident community leading to stress, anxiety, and reduced wellbeing, and possible protest and division within the community.

Impact Assessment

17.63 In-migration leading to tension, impacting social cohesion, possible protest and division, diluting local culture and language, and impacting on community stress, anxiety and wellbeing. Impacts felt locally but over time could lead to regional or national cultural impacts if development initiated at scale.

17.64 Social cohesion and community wellbeing impacts are not explicitly addressed in the UK SEA, the Scottish SEA or the Welsh socio-economic impact assessment study.

17.65 The 2015 MedAct report[112] on unconventional oil and gas developments at a UK level identifies potential effects as a result of an influx of temporary workers including community cohesion, stress, and community divisions.

17.66 The UGEE JRP all island study also notes the potential for changes to local communities as a result of an incoming workforce, and identifies that potential differences in income or lifestyle of highly skilled incoming workers may further complicate impacts on local communities, creating possible tension and division between locals and the incoming workforce. The

[112] https://www.medact.org/wp-content/uploads/2015/04/medact_fracking-report_WEB4.pdf

economic impact assessment presented in Part B suggests that the volume of transitory workers will be fairly modest and temporary, although this does vary to some extent across the development scenarios.

17.67 The JRP report notes that potential community impacts are highly dependent on the level of development. Intensive and widespread unconventional oil and gas developments activities can significantly impact local communities, in both the long and short term. Development that takes place on a smaller scale, is expected to have a smaller potential impact on community character and facilities. It also notes that potential impacts would be dependent on the speed at which development activities occur. Slower, more moderate growth of the industry is likely to result in less acute impacts than rapid growth over a shorter time. While communities naturally change in response to social, demographic and economic conditions, these are normally gradual and a community has time to adapt and accommodate external pressures. When communities experience abrupt or dramatic changes, they are typically experienced as adverse.

17.68 However, the report also emphasises that the way that changes within the community are viewed is subjective, varying from individual to individual, as well as being highly dependent on the scale of the development. The JRP study therefore identifies potential impacts, but does not attempt to classify the scale of the impact or whether it is objectively positive or negative.

17.69 Environmental and community groups commented on the legacy of conflict in NI which has resulted in underlying sensitivities remaining in some communities, affecting community wellbeing.

17.70 Environmental and community groups also identified considerable potential for oil and gas projects to lead to tension and divisions within the local community, even before any physical operations have begun. The existence of live licence applications within NI has been shown to create considerable unrest and concern in those communities, including organised opposition and protest. This was reported by some as bringing the community together to oppose development, but others noted that there are examples where divisions have started to appear within the community in terms of those that oppose or support development, but also in terms of those who are pro or anti protesting as an activity in its own right. There is also the potential for disturbance of local residents, relating to protest activities.

17.71 Recent academic research[113] has shown that younger groups are highly concerned about oil and gas development, particularly unconventional oil and gas developments. There is a gap in existing published evidence in the UK on inter-generational issues, which represents an important impact topic.

17.72 Several stakeholders, as well as correspondence received by the research team, asked that motions recently passed by a number of district councils to ask the Executive to ban all petroleum licensing and to write to the Department for Economy to reject the two current licence applications are noted in the assessment.

Summary

17.73 Receptor sensitivity: whilst the scale of activity under all three development scenarios is not extensive, based on the existing licences in NI, there is considerable community concern already active in some places, and the sensitivity of this receptor has been assessed as medium.

[113] Dunlop, L. et al (2021) "It's our future." Youth and fracking justice in England, *Local Environment*; and Dunlop, L. et al (2020) Corrosive disadvantage: the impact of fracking on young people's capabilities, *Children's Geographies*.

17.74 Type of impact: negative impacts on social cohesion, community wellbeing, and intergenerational justice.

17.75 Type of effect: direct impacts due to site operations and activities, as well as social perceptions of projects, particularly unconventional oil and gas developments (although public perceptions may not distinguish between conventional and unconventional oil and gas).

17.76 Duration of impact: short- to long-term as impacts occur from before anything has happened on-site and the longer term effects on local communities are unknown.

17.77 Reversibility of impacts: there is a lack of evidence. Impacts could be reversible where tension and division stops once projects cease, however, these kinds of impacts are likely to persist in the long term and fundamentally change the character of an area irreversible.

17.78 Significance: therefore, the consequence is expected to be minor under the low and medium scenarios, particularly for unconventional oil and gas development, although in practice communities may not perceive a distinct difference between conventional and unconventional oil and gas development. Consequence is expected to be minor to moderate for the high scenario for conventional and unconventional oil and gas development. The likelihood ranges broadly from unlikely to certain, based on the pre-existence of concern, anxiety and tension in some places, resulting in a significance level of minor to major adverse. There is the potential for transboundary effects, particularly if developments are located close to the border with ROI, but the evidence is not sufficient to assess these definitively.

17.79 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional social cohesion or community wellbeing impacts on the baseline conditions. This is distinct from a policy-based no development scenario, which could help to alleviate existing societal concerns and anxiety about potential development.

Mitigation Measures

17.80 As outlined in the section above on amenity, recreation and physical activity, the UGEE JRP all island study identifies local and regional planning documents are important in defining and protecting a community's character and are the principal way of managing and guiding positive change and mitigating potential negative impacts within a community. It also notes the importance of effective communication and proactive engagement to address concerns and reduce mental wellbeing impacts, and the key points summarised in the section above also apply to social cohesion and community wellbeing impacts mitigation.

Summary table

17.81 The table below summarises the impacts associated with the health impact theme.

Table 17.1 Health Impacts Assessment Summary

Potential Impact	Development scenario	Receptor Sensitivity	Type of Impact	Consequence	Likelihood	Significance
Health and safety	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative	Negligible to Minor	Unlikely	Negligible to Minor adverse
	Medium					

	High					
Public health	No development	Medium	N/A	N/A	N/A	N/A
	Low		Negative	Negligible (for conventional devt) Negligible to Moderate (for unconventional devt)	Unlikely	Negligible to Moderate adverse
	Medium					
	High					
Amenity, recreation and physical activity	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative	Negligible to Minor (esp. for unconventional devt)	Unlikely to Likely (esp. for unconventional devt)	Negligible to Moderate adverse
	Medium					
	High					
Social cohesion and community wellbeing	No development	Medium	N/A	N/A	N/A	N/A
	Low		Negative	Minor	Unlikely to Certain (esp. for unconventional devt)	Minor adverse to Moderate adverse
	Medium					
	High			Minor to Moderate		Minor adverse to Major adverse

17.82 Impacts are expected to be more significant under the high scenario, and less significant under the medium and low scenarios, as well as more significant due to activities associated with unconventional oil and gas developments, as a result of hydraulic fracturing processes and increased requirements for water transportation and infrastructure, compared to conventional oil and gas developments. The effects are also dependent on the siting and phasing of projects, and their proximity to the receptor, and would be controlled to some extent through existing regulatory and planning regimes (although this is less clear for intangible impacts related to mental wellbeing, social cohesion, and community level wellbeing). Under the No Development scenario, there would be no additional impacts on the baseline conditions.

17.83 It is important to note the gaps in available evidence about public health and wellbeing impacts of oil and gas development, particularly unconventional, as well as wider societal concerns, social cohesion and community wellbeing impacts. There is also uncertainty about impacts in the long term, beyond post-closure. More research is required to definitely assess public health and wellbeing impacts on onshore oil and gas development in NI. Amenity and recreation impacts are highly dependent on project specific proposals, including the siting of developments, their proximity to receptors and effects on the accessibility of recreational assets.

18. Landscapes and geodiversity

18.1 This section covers the following topics:

- Landscape and visual effects
- Impacts on natural tourism assets
- Light impacts.

Landscape and visual effects

Sources

18.2 Projects could cause significant landscape and visual effects due to siting, drilling rigs, lighting, flaring, access roads, traffic and HGV movements, fencing, pipelines, generators, storage and processing facilities, portable offices and work facilities, etc.

Impact Assessment

18.3 There is potential for significant landscape and visual effects, particularly impacting communities in close proximity to development sites, as well as the visitor economy. There are also indirect links with the setting of cultural heritage assets, as covered in the preceding section.

18.4 The UK SEA identifies the potential for significant landscape and visual impact from construction activities and associated machinery like drilling rigs. The significance would be dependent on the distribution patterns of well pads, phasing of development, the nature, quality and designations of the receiving landscape, and the extent of visibility to communities. It also notes that the probability of significant landscape effects would be commensurate with the scale of development, including the area of land take required and the density/duration of activity.

18.5 The Scottish SEA of unconventional oil and gas developments also identifies a more significant impact associated with a greater scale of development, finding a significant negative effect for its high scenario for shale gas development, and a minor negative under the mid and low scenarios. It also notes contextual factors such as the location of well pads and potential cumulative effects and likelihood of infrastructure sharing.

18.6 The UGEE JRP all island study does not explicitly deal with landscape and visual effects, and this is covered in the section above on the setting of cultural heritage.

Summary

18.7 Receptor sensitivity: the NI landscape is characterised by its rural nature and high quality landscapes, however, the prevailing regulatory and planning regime would ensure that highly sensitive receptors are protected, and the sensitivity of this receptor is therefore considered to be low.

18.8 Type of impact: landscape and visual effects are negative impacts.

18.9 Type of effect: these represent direct negative effects of oil and gas development activity, as well as potential for indirect effects as a result of adverse impacts on local environmental processes causing further visual effects.

18.10 Duration of impact: landscape and visual effects could occur in the short-, medium- and long-term, occurring across the development lifecycle.

18.11 Reversibility of impacts: impacts could be reversible where they relate to the presence of rigs, traffic, facilities and equipment that will be removed once development activity is complete, however there is also potential for irreversible impacts as a result of pollution and despoilment.

18.12 Significance: As a result of existing regulatory controls, the consequence is expected to be negligible under the low scenario, with potential to increase under the medium and high scenarios, particularly in relation to unconventional oil and gas development and the need for water transportation and associated pipelines, from negligible to moderate, and likelihood is classified as likely, resulting in a significance level of moderate adverse.

18.13 The significance level is dependent on the scale of activity, and it is anticipated that the high scenario is more likely to cause a moderate adverse impact than under the medium or low scenarios, particularly if clustering of development sites occurs.

18.14 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional landscape or visual effects on the baseline conditions.

Mitigation Measures

18.15 Mitigation measures for landscape and visual effects are similar to those for impacts on cultural or archaeological heritage, as provided in the section above. Any potential development should be subject to detailed survey, assessment and establishment of mitigation measures at a project level, and landscape designations are a control along with planning controls. In addition, it is important to determine the local significance of the landscape, and the determination of an appropriate suite of mitigation measures would be heavily dependent on project-specific details and potential impacts.

Impacts on natural tourism assets

Sources

18.16 Projects could damage or degrade natural assets, rural / outdoor visitor economy assets and the livelihoods associated, as a result of land take and site development, drilling rigs, pollution, access roads and traffic, pipelines, fencing, storage and processing facilities, ancillary development, etc.

Impact Assessment

18.17 Damage or degradation to natural assets, impacting particularly on communities in close proximity to the site, as well as the visitor economy and other related livelihoods.

18.18 The UK SEA does not explicitly cover impacts on natural assets, and the Scottish SEA refers to these impacts and references back to cultural and archaeological heritage evidence.

18.19 The Welsh socio-economic impact study notes that there is a lack of evidence that addresses these impacts holistically, and provides a short summary of ex-ante evidence internationally. Similarly to NI, the natural environment outside of the larger urban settlements is key to the Welsh tourism offer, making it a sensitive receptor.

18.20 Consultations with community groups suggest that there is a small but successful natural visitor economy developing in some areas of NI which is highly dependent on its reputation as a clean, green landscape.

Summary

18.21 Receptor sensitivity: NI is characterised by its natural landscapes and it has a growing nature-based visitor economy, making this a sensitive receptor, dependent on well pad siting, proximity of natural assets to the development activity, and the sensitivity of the natural assets. As the prevailing regulatory regime controls for this sensitivity by safeguarding existing tourism assets, it has been identified as low.

18.22 Type of impact: impacts in natural assets would be negative.

18.23 Type of effect: a range of development activity factors could lead to direct negative effects on natural assets, with potential indirect effects caused by pollution and disruption to local environmental processes.

18.24 Duration of impact: impacts could be felt in the short-, medium- and long-term, as they could occur across the development lifecycle.

18.25 Reversibility of impacts: the impacts could be reversible where site restoration activities are completed post-closure, however there is also the possibility of irreversible impacts caused by pollution and despoilment.

18.26 Significance: The consequence is expected to range from negligible under the low scenario but could increase from negligible to moderate as the scale of the proposed activity increases, particularly in relation to the impact of unconventional oil and gas development, due to the increased requirements for water transportation and associated pipelines. Likelihood is classified as unlikely to likely, resulting in a significance level of negligible to moderate adverse.

18.27 The significance level is dependent on the scale of activity, and it is anticipated that the high scenario is more likely to cause a moderate adverse impact than under the medium or low scenarios, particularly if clustering of development sites occurs.

18.28 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional impacts on natural tourism assets compared to the baseline conditions.

Mitigation Measures

18.29 It is assumed that the existing planning regime will avoid development in areas with designated landscapes, dependent on their precise status and importance. In other high quality landscape areas, or areas with high value tourism and where their environmental character is a key component, but which sit outside of formal designations, tourism impact assessment is likely to be an appropriate tool for assessing impacts as part of the EIA scoping process.

18.30 This is confirmed in the Welsh socio-economic impact study which suggests the following controls and mitigation measures:

- Landscape designations are a control along with planning controls

- Comprehensive tourism assessment as part of local planning process on a case-by-case basis to look at the proximity of tourism activities to development sites, and the extent of visual, noise, traffic, air quality impacts on the visitor economy.

Light impacts

Sources

18.31 Projects could lead to an increase in light pollution due to operations at night-time, including floodlighting and flaring, as well as security functions on site.

Impact Assessment

18.32 There is potential for light pollution, impacting the local community, settlements, and habitats and species. Particularly affecting local settlements and communities in close proximity, as well as nearby habitats and species or farm animals.

18.33 Direct impacts on landscape could result from the presence of lighting and related surface equipment. These impacts are greatest during the exploration, appraisal and the early stages of production

18.34 There are some gaps in the available evidence in relation to light pollution impacts, on landscape and visual setting as well as for both human and animal health, particularly in the long-term.

18.35 The UK SEA does not deal with light impacts explicitly, and they are addressed in terms of the impact on biodiversity, flora and fauna, as well as the local community.

18.36 The Scottish SEA identifies light pollution from site activities including floodlighting for safe working or flaring, particularly during the drilling phase which occurs 24 hours a day until complete. Truck movements are also identified as another source of light pollution.

18.37 The study notes that lighting impacts are dependent on the siting and distribution of development, particularly where multiple sites are in close proximity, resulting in cumulative impacts. It also emphasises that the available evidence is uncertain on whether unconventional petroleum associated light pollution would pose a risk to physical health.

18.38 The UGEE JRP all island study also deals with light impacts in relation to impacts on biodiversity, flora and fauna, as well as noting that lighting on site may result in adverse visual intrusion from a distance, as drilling may operate for 24 hours a day especially in or when visible from sensitive high-value agricultural or residential areas.

Summary

18.39 Receptor sensitivity: light pollution is higher in towns, cities and along main transport routes, whereas receptor sensitivity is higher in rural and sparsely populated areas, which is relevant to the NI context. However, existing planning policy will help to control impacts particularly for sensitive receptors, and receptor sensitivity is therefore classified as low.

18.40 Type of impact: negative.

18.41 Type of effect: direct light pollution from site activities and equipment.

18.42 Duration of impact: impacts across the short- to medium-term, based on exploratory, site preparation, drilling and hydraulic fracturing activities.

18.43 Reversibility of impacts: reversible, once lighting on site is ceased. Lighting is mainly required during exploration, drilling and hydraulic fracturing stages, and once projects are in production lighting will be minimal.

18.44 Significance: the significance level is dependent on the scale and intensity of activity, particularly where multiple projects are located in close proximity and unconventional oil and gas development in particular. Therefore, the consequence is anticipated to be negligible to minor, and the likelihood is unlikely to likely, resulting in a significance level of negligible to moderate adverse. It is anticipated that the high scenario is more likely to cause a moderate adverse impact than under the medium or low scenarios.

18.45 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional light related impacts on the baseline conditions.

Mitigation Measures

18.46 The assessment results are based on the application of existing planning and regulatory controls.

18.47 The UK SEA notes that light pollution effects should be mitigated by use of screening, shielding and down lighting where practical.

18.48 The UGEE JRP all island study sets out the following possible lighting design measures which could be appropriate:

- designing lighting to minimise impacts through measures such as the use of low-intensity security lighting, focused task lighting, designing operating lights so that the light levels are as low as safely possible, limiting the height of lighting columns to reduce light spillage, well pad lighting to shine downwards to minimise lighting impacts on sensitive species, and the use of fitted hoods
- siting lighting to minimise off-site light migration, glare, and "sky glow" light pollution

Summary table

18.49 The table below summarises the impacts associated with the landscapes and geodiversity impact theme.

Table 18.1 Landscapes and Geodiversity Impact Assessment Summary

Potential Impact	Development scenario	Receptor Sensitivity	Type of Impact	Consequence	Likelihood	Significance
Landscape and visual effects	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative	Negligible	Likely	Negligible
	Medium			Negligible to Moderate		Negligible to Moderate adverse
	High					
Natural tourism assets	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative	Negligible		Negligible

	Medium			Negligible to Moderate	Unlikely to Likely	Negligible to Moderate adverse
	High					
Light impacts	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative	Negligible	Unlikely to Likely	Negligible
	Medium			Negligible to Minor		Negligible to Moderate adverse
	High					

18.50 Impacts are expected to be more significant under the high scenario, and less significant under the medium and low scenarios, as well as more significant due to unconventional oil and gas development compared to conventional development. The effects are also dependent on the siting and phasing of projects, and their proximity to the receptor, and could be controlled through existing regulatory and planning regimes. Under the No Development scenario, there would be no additional impacts on the baseline conditions.

19. Materials assets

19.1 This section covers the following topics:

- Land use change to industrial use
- Impacts on agricultural land
- Impacts on transport infrastructure
- Impacts on housing, social & community impacts.

Land use change to industrial use

Sources

19.2 Projects could lead to land use change to industrial, from agricultural or other uses, due to land take for well pad development, processing and storage facilities, pipelines, other equipment and infrastructure, temporary offices, ancillary development, etc.

Impact Assessment

19.3 There is potential for projects to cause land use change to industrial, from agricultural or other uses, impacting with significant impact where multiple projects are in close proximity.

19.4 The NI economy has a largely rural character outside of its major towns and cities, and agricultural land is a major feature of its land use. In 2019, over 1 million ha were used for agriculture, 75% of its total land area[114].

19.5 NI also has eight forestry planning areas and 19 forest landscape units[115]. There are high concentrations of forestry in the West Fermanagh Uplands and Antrim Hills and Glens, whereas the area around Lough Neagh has less forested areas.

19.6 According to the UK SEA assumption of 3 ha per conventional well pad (which assumes two wells per pad, as do the development scenarios developed for this study), the total land take for conventional oil and gas exploration and development is anticipated to be in the region of 6 ha under the low scenario, 9 ha under the medium and 15 ha under the high scenario.

19.7 For unconventional oil and gas development, the assumptions from the UK SEA have been applied as they are more conservative at 3 ha per well pad, as opposed to the available evidence in the Scottish SEA which is 0.8 ha per pad. Under the development scenarios developed for this study, the total land take for unconventional oil and gas developments is anticipated to be in the region of 3 ha under the low scenario, 6 ha under the medium scenario, and 12 ha under the high scenario.

19.8 Therefore, according to the UK SEA assumptions, the total land take for both conventional and unconventional development would be in the region of 9 ha under the low scenario, 15 ha under the medium and 27 ha under the high scenario.

[114] https://www.daera-ni.gov.uk/sites/default/files/publications/daera/Stats%20Review%202019%20final.pdf

[115] Department of Agriculture, Environment and Rural Affairs, Forestry Planning Areas and Forest Landscape Units, 2018

19.9 The UK SEA identifies most significant effects during construction and pad development stages, when clearance is required for pad prep and provision of associated infrastructure. It also notes that receptor sensitivity will vary according to the previous land use, as well as if these lie adjacent to development sites. Sensitivity will be increased where this is previously high-quality agricultural land or other sensitive areas. However, impacts in the long term could be positive if development uses previously developed land.

19.10 It also notes there are likely to be short to medium term cumulative effects due to land take, soil loss and compaction, as well as the potential for long term positive impacts beyond site restoration due to soil quality being restored and prospects for beneficial use.

19.11 The Scottish SEA of unconventional oil and gas developments identifies similar impacts relating to land use change to industrial uses, impacting on mineral resources, forestry and woodland, as well as agricultural land. It notes that the likely location of pads could result in impacts on land with greatest suitability for agriculture or forestry and woodland production. These impacts would be greater under the high scenario, and less significant under medium and low scenarios used in that SEA. The study also identifies potential cumulative impacts from land use change combining with increasing traffic levels resulting in the urbanisation of the countryside and potential negative effects on environmental quality, as well as secondary effects through the construction of waste treatment facilities.

19.12 It should be noted that within the NI context, forestry and woodland uses would be less suitable than agricultural land, being mainly uplands, as well as more sensitive deciduous and ancient woodland receptors being protected under prevailing regulatory and planning regimes.

19.13 The UGEE JRP all island study also identifies land use change impacts, and focuses on agricultural land impacts as presented in the following section.

Summary

19.14 Receptor sensitivity: sensitivity will vary according to the current use of the land, with highest sensitivity associated with previously productive uses and high-quality agricultural land. However, prevailing regulatory and planning controls will protect sensitive receptors, and the sensitivity of the receptor is identified as being low.

19.15 Type of impact: negative, possible positive impacts after restoration if development uses previously developed land.

19.16 Type of effect: direct, with potential indirect effects from the construction of waste treatment facilities.

19.17 Duration of impact: long-term, across the development lifecycle.

19.18 Reversibility of impacts: impacts are reversible where appropriate site restoration takes place.

19.19 Significance: therefore, the consequence is expected to range from negligible under the low development scenario, potentially increasing to minor under the medium and high scenarios, and likelihood is classified as unlikely based on existing controls, resulting in a significance level of negligible to minor adverse.

19.20 The significance level is dependent on the scale of activity, as well as the siting and phasing of activity, and it is anticipated that the high scenario is more likely to cause a minor adverse impact than under the medium or low scenarios, particularly if there is clustering of activity in a smaller geographical area.

19.21 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional land use change to industrial use impacts on the baseline conditions.

Mitigation Measures

19.22 The prevailing regulatory and planning policy controls represent the main mitigation mechanisms for land use change.

Impacts on agricultural land

Sources

19.23 Projects could cause degradation to agricultural lands as a result of dust, air, land and water pollution, as well as light and noise nuisance, and the impact of increased traffic.

19.24 The UGEE JRP all island study suggests that impacts will occur during the drilling and development phase if there are conflicts with existing or planned agricultural activities. It relates the potential impacts on agricultural activities and animals through the following:

- water depletion
- water contamination and surface water quality
- neighbouring land uses
- degradation of soils
- noise
- public perception.

Impact Assessment

19.25 There is potential for impact , in particular on agricultural land in close proximity to sites, and on crop and animal health and agricultural livelihoods.

19.26 As outlined in the section above, agricultural land is a major feature of NI land use. In 2019, over 1 million ha were used for agriculture, 75% of its total land area[116]. In 2017, there were 25,000 farms across NI, of which the south-west of NI contains the highest numbers with over 5,000 farms in the district of Fermanagh and Omagh[117]. Consultations with community groups have suggested that in certain areas of NI, such as Fermanagh and Omagh, there is also a small but growing food-based visitor economy associated with this agricultural nature and public perception of high-quality environment and associated food products. This is confirmed by the UGEE JRP all island study which notes that the agri-food sector is currently acknowledged to be on a path of sustainable growth, based on emission-efficient food production and high animal welfare, environmental and agronomic standards.

[116] https://www.daera-ni.gov.uk/sites/default/files/publications/daera/Stats%20Review%202019%20final.pdf

[117] http://www.ninis2.nisra.gov.uk/InteractiveMaps/Agriculture%20and%20Environment/Agriculture/Farm%20Census/atlas.html

19.27 The UGEE JRP all island study outlines the following impacts:

- soil impacts leading to reduced agricultural productivity
- loss of available grazing or crop land
- the potential for the introduction of invasive plants that could affect the availability of livestock forage
- possible increases in livestock– vehicle collisions when it is necessary to move livestock across access roads
- noise as a stressor if it occurs where farm or domestic animals are located, affecting their behaviour and productivity or inducing physiological changes, and is known to be detrimental to animal health (although it notes that many species appear to adjust to some forms of sound disturbance)[118]
- adverse impacts on farm animals relating primarily to accidents and spillages, including the accidental release or leakage of fracking fluids which can lead to animal deaths and reproductive problems
- negative impact on the perception of the island of Ireland as a green, unpolluted country resulting in a knock-on effect on the agri-food industry, negatively impacting commercial interests.

19.28 As outlined in the section above, the UK SEA identifies that receptor sensitivity will vary according to the intensity of development, and the proximity of development to high quality agricultural lands. The Scottish SEA notes that the likely location of pads could result in impacts on land with greatest suitability for agriculture as well as potential cumulative impacts resulting in the urbanisation of the countryside and secondary effects through the construction of waste treatment facilities.

Summary

19.29 Receptor sensitivity: receptor sensitivity will vary according to the concentration of agricultural land and proximity to development sites. However, prevailing regulatory and planning controls will protect sensitive receptors, specifically through the EIA scoping process, and the sensitivity of the receptor is identified as being low.

19.30 Type of impact: impacts are negative.

19.31 Type of effect: direct, with potential for indirect impacts where wind or water patterns transport pollution to non-adjacent agricultural land.

19.32 Duration of impact: long-term, experienced across development lifecycle.

19.33 Reversibility of impacts: reversible where effects cease after development activity is complete, but there is potential for irreversible effects including livestock deaths and effects on reproductive functions, and degradation to soils and crops.

19.34 Significance: therefore, the consequence is expected to range from negligible under the low development scenario, potentially increasing to minor under the medium and high scenarios,

[118] The report suggests that the hydraulic fracturing process is likely to be the loudest site activity and can produce noise levels of 90 dBA at a distance of 75 m. Whilst dependent on the location of sites, number of well pads, types and numbers of sensitive receptors and the application of appropriate mitigation measures, this level of noise is still likely to be of "moderate" impact, or "significant" for receptors such as farm environments within 300 m of activities.

particularly in relation to unconventional oil and gas development. Likelihood is classified as unlikely based on existing controls, resulting in a significance level of negligible to minor adverse.

19.35 The significance level is dependent on the scale of activity, and it is anticipated that the high scenario is more likely to cause a minor adverse impact than under the medium or low scenarios.

19.36 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional impacts on agricultural land compared to the baseline conditions.

Mitigation Measures

19.37 The prevailing regulatory and planning policy controls represent the main mitigation mechanisms for potential impacts on existing uses. The UGEE JRP all island study identifies the following mitigation measures to minimise the potential impacts on agricultural land, animals and crops:

- sensitive location of well pads and the avoidance of land use conflicts
- liaison with local farmers to minimise potential impacts on agriculture
- proper disposal of cuttings
- prohibition and removal of spent drilling muds from productive agricultural fields
- locating well pads and access roads along field edges and in non-agricultural areas (where practicable)
- fencing the site when drilling is located in or adjacent to productive pasture areas to prevent access by animals
- establishing safeguards to prevent leaks and spillages.

Impacts on transport infrastructure

Sources

19.38 Projects could impact on existing or planned transport infrastructure due to HGV movements, traffic/congestion, migrant workforce usage, and/or due to siting decisions. Unconventional oil and gas development has higher requirements for water transportation, both to and from the site as wastewater, which represents an enhanced source of impact due to the vehicle movements this can result in.

Impact Assessment

19.39 Local to regional impacts are possible on the transport infrastructure systems, resulting in effects to local communities, commuters, and visitors to the area. Unconventional oil and gas development in particular, can result in increased traffic levels of both light vehicles associated with employee car trips and HGVs associated with site activities, as outlined in the section on air quality impacts related to traffic and construction activities.

19.40 Impacts on transport infrastructure are not directly covered in the UK level SEA, and the Scottish SEA deals with the impacts of pad development on infrastructure in general. It notes that the sensitivity of infrastructure receptors would be dependent on the use of pipelines for water transportation which reduces the overall number of vehicle movements required.

19.41 The Welsh community transport study addresses impacts on transport infrastructure, identifying that vehicle movements occur across all stages of unconventional oil and gas development. Increases in vehicle movements are anticipated to be highest during exploration and development and to decrease during production, drawing on assumptions from the UK SEA. However, the volume of movements is dependent on the number of wells and their phasing, the volumes of water needed, how it is sourced and transported, volumes of waste and wastewater generated, the methods and location of water treatment, and the manner that extracted gas is removed from the site. This could lead to negative impacts such as congestion on local roads, but the Welsh study suggested that its road infrastructure would be capable of absorbing this.

19.42 The study also finds that the significance of effects would be dependent on location, with urban areas would be more likely to absorb additional movements, whereas smaller scale more rural communities with limited scope for additional routes would be more significantly impacted. This is confirmed in the UGEE JRP all island study, and is of direct relevance to the context of NI.

19.43 According to a 2017 study into the community impacts of transportation activities associated with potential unconventional oil and gas in Wales, there are six potential effects on local communities as identified in the previous study undertaken in the Scottish context, which includes potential for accelerated road surface degradation.

19.44 The UGEE JRP all island study deals with impacts on transport infrastructure across the island of Ireland, identifying that truck movements are needed across the development lifecycle, including exploration and site preparation, construction, hydraulic fracturing, and production. Sources include the transport of fresh water, additives, proppant, management of flowback, for site construction, and during the drilling stage. There would be much fewer traffic movements associated with end of project, decommissioning and restoration stages, and those associated with post-closure environmental monitoring would be minimal.

19.45 There is potential for impacts across exploration, development and production stages to result in damage to existing infrastructure due to the degradation of roads and bridges reducing road quality, congestion and effects on road safety due to risks of spillages, accidents, and potential community severance. The JRP report notes that if a number of well pads are simultaneously developed in a given area, the potential for adverse effects could be increased due to a sustained increase in the number of HGVs in one area. The sensitivity of the receptor is likely to be further increased if there is a single route needed for the development of a high number of pads, which could lead to a combination of increased numbers of vehicles and extension to the period of site development.

19.46 The report states that impact associated with an individual site is considered to be minor due to the short duration, but it could be noticeable by local residents. However, the impact of traffic associated with more widespread development may be of moderate significance. Classifying the magnitude of impacts would depend on the details of individual project proposals.

Summary

19.47 Receptor sensitivity: the sensitivity is dependent on the scale of activity as well as the siting and phasing of multiple projects, but due to the relatively modest levels of activity in the development scenarios and existing regulatory controls, this receptor has been classified as low (noting that this is in relation to impacts on transport infrastructure, and the air quality, noise and other effects of site-related traffic are dealt with elsewhere in this assessment).

19.48 Type of impact: negative impacts related to potential congestion, damage, and degradation of infrastructure.

19.49 Type of effect: direct impacts on transport infrastructure.

19.50 Duration of impact: impacts could be felt in the short- to medium- term being mainly associated with site preparation, construction and production activities. Phasing of multiple sites in close proximity could increase this to the long-term.

19.51 Reversibility of impacts: impacts are reversible if managed appropriately, and infrastructure is maintained and repaired when required.

19.52 Significance: therefore, the consequence is expected to be negligible and likelihood is unlikely, resulting in a significance level of negligible. There could be potential for cumulative impacts if multiple developments are sited in close proximity and activities are phased in a similar manner, and for transboundary impacts dependent on the siting and clustering of development sites in close proximity to the border with ROI.

19.53 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional transport infrastructure impacts on the baseline conditions.

Mitigation Measures

19.54 The prevailing regulatory and planning policy controls represent the main mitigation mechanisms for potential impacts on existing uses.

Impacts on housing social & community infrastructure

Sources

19.55 Projects could cause an increase in demand and/or pressure on housing, services and social and community infrastructure due to transient workforces, arising from economic growth and influx of workers into local communities, especially if rural and where there is commencement of development at scale.

Impact Assessment

19.56 Influx of workers into local and likely rural areas could result in impacts on housing, services, social and community infrastructure, particularly impacting on local communities close to the project site.

19.57 There is a lack of UK based evidence available to understand these impacts either in the short-term, during the development lifecycle, after development activity has ceased, or in the longer-term beyond post-closure.

19.58 A 2015 report[119] from MedAct on unconventional development activity at a UK level identifies the following potential effects, including the influx of temporary workers, and resultant pressure on local services. This includes the potential impacts of alcohol and drug use, mental illness,

[119] https://www.medact.org/wp-content/uploads/2015/04/medact_fracking-report_WEB4.pdf

violence, community cohesion, stress, and community divisions, all furthering increasing potential pressure on local services. However, these effects are not assessed in a structured way and there is a lack of evidence available to address the long-term impact beyond the lifetime of the project, and beyond post-closure.

19.59 The UK SEA does not explicitly cover impacts on housing, services, or social and community infrastructure. It includes some discussion about host community benefits associated with community contributions or funds from shale gas exploration and production, and references the UKOOG 2013 Community Charter requirement of £100,000 per well pad, as well as a figure of community benefits at c. 1% of revenue from production. However, there is no detailed assessment of how these community funds are delivered and managed, and how they translate into recognised benefits by the community.

19.60 The Welsh socio-economic impact assessment also addresses community benefit packages based on the same assumptions as the UK SEA, but there is again no assessment of how these funds translate into recognised community benefits. The study also notes that in England, there would also be fiscal revenue attributing to local councils through business rates. This does not currently apply in NI as powers relating to business rate-raising are devolved, but to date no action has been taken on measures for onshore activities.

19.61 The Scottish SEA on unconventional oil and gas developments does not explicitly address impacts on housing, local services or infrastructure.

19.62 The UGEE JRP all island study does address these impacts. It finds that local communities within study areas that may have been historically stable or declining may experience a degree of growth or temporary increase with transient workers, with an associated increase in the demand on local services.

19.63 It also notes that new employment sectors, such as suppliers to the unconventional oil and gas sector, may expand. Employment opportunities may then increase in the communities, with an associated potential increase in local population. New residents would be of working age (employees) or younger (their dependents). In some areas, the housing market may experience an increase in house prices or rents if there is not sufficient supply to meet the increased demand.

19.64 It should be noted that the highest estimates produced as part of the economic impact assessment undertaken for this study suggest in the region of 22 person years of employment would be supported per year per well pad over a thirty-year period. Further, the additional demand for hospitality, food and drink and retail services would support in the region of 15 person years of employment per well pad, in total. This would be mainly concentrated during a 3-5 year period associated with drilling and hydraulic fracturing.

19.65 At a national level, housebuilding in NI has exceeded population growth with the total stock per 1,000 population increasing from 409 units per 1,000 people in 2008/09 to 422 units per 1,000 people in 2019/20.[120] However, 20% of NI's housing stock is contained within Belfast and of all other districts, Fermanagh and Omagh has the lowest level of housing stock.

Summary

19.66 Receptor sensitivity: whilst there is a lack of evidence available, the development scenarios do not involve commencement of activity at scale, the economic impact assessment has shown

[120] https://www.communities-ni.gov.uk/publications/northern-ireland-housing-statistics-2019-20

that even under the high scenario the employment effects are modest, and when combined with existing planning policy controls, the sensitivity of this receptor is classified as low.

19.67 Type of impact: negative, noting that there is a lack of evidence about the translation of community benefit packages into recognised benefits. There is potential for positive effects for rural communities which are in decline, stimulating (at a fairly low level) demand for housing and local services and amenities.

19.68 Type of effect: direct impacts on services by transient workforce, as well as potential indirect effects caused by an increase in local employment opportunities causing a growth in population (noting there is a lack of evidence available to assess this properly).

19.69 Duration of impact: medium- to long-term, based on the presence of a transient workforce and potential longer term impacts beyond post-closure.

19.70 Reversibility of impacts: reversible impacts on local services, although the subsequent impacts on the local community in the longer term could be irreversible, such as blighted life chances as a result of not being able to access services when required.

19.71 Significance: whilst there is a lack of long-term evidence combined with the unknown nature of these impacts, due to the relatively low scale of the development scenarios and existing planning policy controls, the consequence is assessed as ranging from negligible to minor, as well as potential for positive consequence, under all development scenarios and the likelihood is unlikely, resulting in a significance level of positive and negligible to minor adverse.

19.72 The significance level is dependent on the scale of activity, and it is anticipated that the high scenario is more likely to cause a minor adverse impact than under the medium or low scenarios, although the relationship between conventional and unconventional oil and gas developments activity and impacts on housing and other services is not clear based on available evidence. There could be potential for transboundary impacts dependent on the siting of development sites and incoming transient workforce populations.

19.73 Under the No Development scenario, there would be no occurrence of oil and gas development activities meaning there would be no additional impacts on housing, social and community infrastructure compared to the baseline conditions.

Mitigation Measures

19.74 The prevailing regulatory and planning policy controls represent the main mitigation mechanisms for potential impacts on existing uses, primarily through the EIA scoping process, and developers could be required to undertake assessment of possible impacts on housing and social and community infrastructure, where there is concern about potential negative impacts. This is confirmed in the UGEE JRP all island study, which identifies local and regional planning documents as important in defining and protecting the character of a local area and are the principal way of managing and guiding positive change and mitigating potential negative impacts.

Summary table

19.75 The table below summarises the impacts associated with the materials assets impact theme.

Table 19.1 Material Assets Impact Assessment Summary

Potential Impact	Development scenario	Receptor Sensitivity	Type of Impact	Consequence	Likelihood	Significance
Land use change to industrial use	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative, possible long term positive after site restoration	Negligible	Unlikely	Negligible
	Medium			Negligible to Minor		Negligible to Minor adverse
	High					
Impacts on agricultural land	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative	Negligible	Unlikely	Negligible
	Medium			Negligible to Minor		Negligible to Minor adverse
	High					
Impacts on transport infrastructure	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative	Negligible	Unlikely	Negligible
	Medium					
	High					
Impacts on housing, services, social and community infrastructure	No development	Low	N/A	N/A	N/A	N/A
	Low		Negative, potential for positive	Negligible to Minor, and possible Positive	Unlikely	Positive / Negligible to Minor adverse
	Medium					
	High					

19.76 Impacts are expected to be more significant under the high scenario, and less significant under the medium and low scenarios, as well as more significant due to unconventional projects compared to conventional projects. The effects are also dependent on the siting and phasing of projects, and their proximity to the receptor, and would be controlled for through existing regulatory and planning regimes. Under the No Development scenario, there would be no additional impacts on the baseline conditions.

20. Overview of Social & Environmental Assessment

20.1 The environmental and social impact assessment of the potential for onshore petroleum exploration and development in NI has drawn on a combination of qualitative and quantitative evidence drawn from existing Strategic Environmental Assessments (SEAs) in the UK on onshore oil and gas development and other publicly available research reports covered in the review.

20.2 This is a high-level assessment of the significance of potential impacts. It is neither a Strategic Environmental Assessment (SEA), a project-level Environmental Impact Assessment (EIA), nor a project-specific Environmental and Social Impact Assessment (ESIA). Similarly, the assessment of health themes is not a Health Impact Assessment (HIA).

20.3 We have adopted a consistent approach to the assessment of environmental and social impacts and evaluation criteria used to determine impact significance. This has assumed the prevailing planning policies and environmental regulations control activities to prevent pollution and nuisance to sensitive receptors. The mitigation measures outlined above could be implemented, among others, as part of the licence conditions and as good industry practice on a site-by-site basis. However, the effectiveness of the implementation and regulation of past, current or future planning policies and laws covering NI is not within the scope of this assessment.

20.4 The assessment concludes that under the no development scenario there would be no additional social and environmental impacts on the baseline conditions. As this scenario does not reflect a change in the current position for onshore development, the potential benefits and disbenefits of such a change are not considered.

20.5 The low development scenario is assessed as having potential effects of moderate adverse significance for the following topics:

- Noise and seismicity: felt seismicity (unconventional only)
- Health: Public health; amenity, recreation and physical health; social cohesion and community well-being.

20.6 In the assessment, environmental topics, compared to a number of health-related topics noted above, are generally found to be lower significance under the low development scenario as assumptions are made of a smaller footprint or influence in the context of the regional or national resource. However, as noted below, some of these topics are subject to aspects of uncertainty which could affect this assessment.

20.7 The medium development scenario is assessed as having potential effects of at least moderate adverse significance for the following topics:

- Soils: loss of soils
- Water: groundwater and surface water extraction and pollution
- Climate change: GHG emissions (unconventional only)
- Noise and seismicity: felt seismic activity (unconventional only)
- Health: public health; amenity, recreation and physical health; social cohesion and community well-being

- Landscapes and Geodiversity: landscape and visuals; natural tourism assets; light impacts (in this instance, the potential for moderate adverse effects is assessed to be greater where there is clustering of developments in close proximity to each other). The impacts may be greater, in some regards, for unconventional drilling.

20.8 The high development scenario is assessed as having potential effects of at least moderate adverse significance for the following topics:

- Air quality: point-source and fugitive emissions; air quality impacts associated with construction and site traffic; dust
- Soils: loss of soils; loss of soil quality or productivity; impact on biodiversity or agriculture
- Waste management: handling, storage and disposal of waste
- Climate change: GHG emissions (both conventional and unconventional)
- Biodiversity, Flora and Fauna: habitat loss, disturbance and fragmentation
- Noise and seismicity: felt seismic activity (unconventional only)
- Health: public health; amenity, recreation and physical health
- Landscapes and Geodiversity: landscape and visuals; natural tourism assets; light impacts (again, in this instance, the potential for moderate adverse effects is assessed to be greater where there is clustering of developments in close proximity to each other).

20.9 The significance of the effects under the high development scenario for the groundwater abstraction and pollution and social cohesion and community well-being receptors is assessed as being of major adverse significance.

20.10 There are potential environmental impacts where the gaps in the available evidence makes a reliable assessment of the consequences of development and the scope for regulatory control and good practice to adequately manage them challenging. This applies to all of the development scenarios which have been assessed in this report. The UGEE JRP all island study concludes that there is significant uncertainty around the following topics in particular:

- Groundwater aquifers could be polluted as a result of the failure or deterioration of well integrity
- These aquifers could also be polluted by the migration of pollutants and gas to the aquifer as a result of the fracking process
- The long term leakage of gas after well closure.

20.11 The review and impact assessment in the context of NI has identified other gaps in the available evidence. These include gaps around the long term public health impacts beyond post-closure, as well as cumulative or transboundary effects for either physical or mental health and wellbeing and the lack of available evidence about the impact of induced seismic events on people, including their physical health and safety, as well as less tangible impacts on mental wellbeing, anxiety and stress.

20.12 Uncertainty also exists regarding impacts from the combination of emissions from onsite machinery, HGVs, drilling and fracturing which could lead to cumulative negative effects on sensitive receptors, the impact on water resource availability, water quality and aquatic habitats and ecosystems and the fragmentation of terrestrial habitat due to development.

20.13 It is important to note and acknowledge that many potential impacts are site-specific and will vary depending on the sensitivity of local receptors and the prevailing environmental and social conditions. Within the scope of this study, it is challenging to assess these beyond high level or general terms, and the assessment does not include explicit statements about receptors and potential impacts for specific sites and their neighbouring communities which could be the focus of future development applications.

Appendix A - Coverage of Socio-economic and Environmental Themes

Economic, Social and Environmental Topics and Impact Pathways

	Theme	Topic	Impact pathway
Potential Environmental Impacts	Air	Fugitive emissions to air impacting air quality and human health	Emissions to air can come from on-site machinery and drilling activities. Particularly impacting on people with respiratory conditions, children and older people.
		Dust impacting air quality at a local level, nuisance and human health	Dust emissions particularly during site preparation and construction at a project site. Particularly impacting on people with respiratory conditions, children and older people, at a local level.
		Construction and site traffic impacting through congestion, associated air quality and noise, nuisance and health	Emissions to air can come from HGV movements and other traffic. This can be high frequency at unconventional projects. Particularly impacting on local communities in proximity.
	Water	Water abstraction and supply impacting on ground water sources	Water required in exploration and particularly in extraction process. Groundwater not used for drinking water across majority of NI.
		Water disposal, wastes, pollution (chemicals) impacting on groundwater quality and animal/human health	Water discharges and management of other wastes (fillings, chemicals) can pollute ground water sources with implications for livestock farming and animal health.
	Soil	Ground contamination impacting flora, fauna and animal health, possibly human health	Projects could cause ground contamination if leakages of water and wastes occur. Potentially impacting on local farming livelihoods and animal health.
		Damage to soils impacting on soil quality and biodiversity, and farming livelihoods	Projects could damage soil quality, cause degradation. Impacting on biodiversity and natural capital, farming and agricultural livelihoods.
	Climatic factors	Controlled and uncontrolled release of produced gas impacting on air quality and health	Projects could lead to the controlled and uncontrolled release of produced gases through exploration, drilling activities, and fracturing processes. Particularly impacting on local air quality and human health.
		Combustion of gas or fossil fuels for on-site power and for transportation	Combustion of gas and fossil fuels due to project energy demands, particularly in unconventional projects, as well as increased transportation needs, HGV movements, etc. Impacting on emission levels, air quality, and local health.
		Greenhouse gas emissions associated with land use change impacting air quality and carbon commitments, possible divestment campaigns	Projects leading to significant change in land use could lead to significant levels of greenhouse gas emissions, particularly multi-project sites and unconventional developments. Impacting on strategic climate change commitments and air quality, possible divestment campaigns.
	Biodiversity, flora and fauna	Habitat disturbance, loss and fragmentation impacting species, animal health, food chains	Habitats and biodiversity can be affected by developments through the removal of vegetation, reduction in habitats or interference with green corridors or other linkages. Impacting on local species, animal health, food chains.
		Loss of flora and fauna species impacting biodiversity and ecosystems	Projects could impact the flora and fauna of a site through removal of vegetation, reduction in habitats, individual effects on species through e.g. traffic, dust, water, pollution. Leading to wider impacts on biodiversity of flora and fauna and ecological system impacts.
		Invasive non-native species impacting on native species and ecosystems	Projects could disrupt native ecosystems causing conditions for non-native species to invade local environments, as well as transporting non-native species into the area due to migrant workforce and large-scale equipment being brought in. Impacting particularly on local biodiversity, flora and fauna, food chains, animal health.
		Climate change impacts on habitats and species	Projects could cause significant increases in greenhouse gas emissions leading to climate change impacts causing degradation in vegetation, biodiversity, habitats and species. Impacting at a widespread scale.

Potential Social and Economic Impacts	Cultural and archaeological heritage	Loss and/or damage of known and unknown archaeology, and other designated and undesignated historic assets	Projects could knowingly or unknowingly cause loss or damage to archaeological and historic assets as a result of exploration, drilling, pollution, traffic, etc. Impacting on local assets and wider cultural identity, possible impacts on visitor economy.
		Impacts on setting of cultural heritage	Projects could damage or impact on the wider setting of cultural heritage assets, landscape and visual setting, accessibility, etc. Impacting on asset cultural value, recreation and amenity, visitor economy.
	Landscapes and geodiversity	Landscape and visual effects	Projects could cause significant landscape and visual effects due to siting, equipment on site, traffic and HGV movements, etc. Impacting particularly communities in close proximity to site, as well as visitor economy.
		Natural tourist sites	Projects could damage or degrade natural assets and rural / outdoor visitor economy and livelihoods associated.
	Material assets	Land use change to industrial	Projects causing land use change to industrial with significant impact where projects are multi-site or unconventional.
		Impacts on agricultural land	Projects could cause degradation to agricultural lands as a result of dust, air, land and water pollution, impacting crop health and agricultural livelihoods.
		Impacts on transport infrastructure	Projects could impact on existing or planned transport infrastructure due to HGV movements, increased traffic/congestion, migrant workforce usage, or due to siting decisions. Local to regional impacts possible on local communities, commuters, visitors to the area.
		Impacts on housing, services, social and community infrastructure	Projects could cause an increase in demand on housing, services and social and community infrastructure due to migrant workforces. Particularly impacting on local communities close to project site.
		Impacts on tourism and visitor economy infrastructure	Projects could cause an increase in demand for visitor economy infrastructure (e.g. hotel beds), leading to decreased accessibility, availability and amenity value for local communities, tourists and other visitors. There could be positive impacts for visitor economy livelihoods due to increase in demand.
	Population	Noise, impacting local community and settlements	Projects could cause noise nuisance due to exploration, construction, drilling and fracturing activities, traffic and HGV movements. Particularly affecting local communities and settlements as well as those on key transportation routes.
		Light pollution, impacting local community and settlements and local habitats and species	Projects could lead to increase in light pollution due to operations at night-time as well as security on site. Particularly affecting local settlements and communities in close proximity, as well as nearby habitats and species or farm animals.
		Air quality, dust and odour nuisance	Projects could lead to increases in dust, air pollution and odor nuisance due to construction, drilling and fracturing, traffic and HGV, release of gases, etc. Particularly affecting local communities in close proximity or along key transport routes.
		Felt seismic activity	Projects could lead to seismic activity being experienced locally due to fracturing activity. Particularly impacting local communities, possible perceptions of safety, demand for local housing and other services, and possible implications for local visitor economy.

		In-migration of workers damaging social cohesion, diluting culture and language	Projects could lead to high levels of in-migration to supply skilled labour to the site, causing tension and impacting social cohesion, diluting local culture and language. Impacts felt locally but over time could lead to regional or national cultural impacts.
		Demonstrations and civic unrest	Project proposals and developments may lead to demonstrations and civic unrest, which will require policing and civil resources, and impose various costs on local communities
	Health	Amenity, mental wellbeing, recreation and physical activity	Projects could lead to decrease in healthy living, including decreased physical activity, recreation and amenity activities and impacts on mental wellbeing, due to nuisance, environmental contamination and pollution effects preventing physical and leisure activities outdoors, outdoor visitor economy, etc. Particularly impacting people local to the project site.
		Physical health and safety	Project sites could lead to health and safety risks to workers and local residents.
		Road traffic accidents	Projects could lead to increased road traffic accidents due to HGV and car trips associated with exploration and production activity.
		Increased Radon seepage risks	Projects could impact on Radon gas pathways.
	Socio-economic	Increased economic output and GVA	Projects would provide additional economic output, GVA, salaries and tax income (business rates) within NI; expenditure that would have otherwise leaked out of the NI due to the purchase of O&G or associate feedstocks.
		Employment opportunities, including rural opportunities for young people	Projects could bring economic opportunities through the training and job opportunities associated directly with exploration and production activity, and in the supply chain.
		Supply chain opportunities	Projects could bring economic opportunities for businesses in the supply chain, and associated training and job opportunities.
		Reduced employment and income from tourism	The possibility that production scale activity may impact, directly or indirectly, on a range of sectors from agriculture to tourism. This could be both benefits and disbenefits. These effects could be both through real or perceived effects (e.g. the perception that an area is not as attractive or appealing for tourism due to development activity).
		Downstream economic benefits	Opportunities arising from NI production leading to improved access to, and possibly reduced costs of, feedstocks (e.g. through lower transport costs); this could also help to support the case for the investment in new facilities
		Impacts on agriculture e.g. reduction in yields, animal health, quality of products.	As for tourism above, projects could impact on the agriculture sector and its products, directly or indirectly.
		Energy market impacts	Arising from increased self-reliance of Northern Ireland, enhanced energy security and possible efficiency effects linked to lower energy costs.
		Pressure on housing, services, social and community infrastructure	Arising from economic growth and influx of workers into local communities, especially if rural, due to the commencement of development at scale.
	Cross-border issues	There may be specific cross-border issues which are relevant for many of the topics above	Projects, possibly depending on nature and location, may raise economic, social or environmental cross border considerations

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