

<b>Title:</b> SI to define protected areas under section 4B of the Petroleum Act 1998 and commencement of section 50 of the Infrastructure Act 2015 <b>IA No:</b> DECC0191 <b>Lead department or agency:</b> Department of Energy and Climate Change (DECC) <b>Other departments or agencies:</b> Defra, Environment Agency, Oil and Gas Authority	<b>Impact Assessment (IA)</b> <b>Date:</b> 13 July 2015 <b>Stage:</b> Final <b>Source of intervention:</b> Domestic <b>Type of measure:</b> Secondary Legislation <b>Contact for enquiries:</b> Mike Earp 03000 685784 <a href="mailto:mike.earp@oga.gsi.gov.uk">mike.earp@oga.gsi.gov.uk</a>
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## Summary: Intervention and Options

**RPC:** GREEN

Cost of Preferred (or more likely) Option				
Total Net Present Value	Business Net Present Value	Net cost to business per year (EANCB in 2009 prices)	In scope of One-In, Two-Out?	Measure qualifies as
-£40.0 million	-£40.0 million	£1.98 million	Yes	IN

### What is the problem under consideration? Why is government intervention necessary?

Sections 4A and 4B of the Petroleum Act 1998 were inserted by section 50 of Infrastructure Act 2015. Section 4A ("Onshore hydraulic fracturing: safeguards") sets out conditions that must be met before a hydraulic fracturing consent can be given in respect of an onshore licence for England and Wales. The section bans hydraulic fracturing within protected groundwater source areas and other protected areas. Regulations, which must be made by statutory instrument (SI), are required to specify (a) the descriptions of areas which are "protected groundwater source areas" and (b) the descriptions of areas which are "other protected areas" for the purposes of section 4A of the Act. Section 4B(6) requires the Secretary of State to lay draft regulations under section 4B(4) before each House of Parliament by 31 July 2015. It is intended that section 50 will be commenced following Parliamentary approval of the regulations, expected in autumn 2015.

### What are the policy objectives and the intended effects?

The newly inserted sections of the Petroleum Act introduce conditions for a well consent that is required by an onshore licence for England and Wales. These prohibit hydraulic fracturing at depths of less than 1,000 metres and introduce conditions required for a hydraulic fracturing consent. These safeguards reinforce the existing regulatory regime, to ensure that the development of shale gas in the UK proceeds in a safe and environmentally sound way. The extent of the effect on hydraulic fracturing operations will depend on the size and location of protected areas.

### What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

Various options have been considered for the extent of the protected areas. There is a balance to be struck between the economic benefits from allowing hydraulic fracturing everywhere and excluding access to the hydrocarbons in some areas that are deemed to merit special protection (eg groundwater source areas and National Parks). The chosen option affords additional protections for National Parks, Areas of Outstanding National Beauty and World Heritage Sites and represents a narrower scope in respect of the definition of protected areas, thereby minimising the consequential loss of activity and economic benefit. The legislation requires a draft SI defining protected areas to be laid before each House of Parliament on or before 31 July 2015.

### Will the policy be reviewed? Yes. If applicable, set review date: 2020

Does implementation go beyond minimum EU requirements?			N/A		
Are any of these organisations in scope? If Micros not exempted set out reason in Evidence Base.	<b>Micro:</b> Yes	<b>&lt; 20:</b> Yes	<b>Small:</b> Yes	<b>Medium:</b> Yes	<b>Large:</b> Yes
What is the CO <sub>2</sub> equivalent change in greenhouse gas emissions? (Million tonnes CO <sub>2</sub> equivalent)			<b>Traded: 0</b>		<b>Non-traded: 0</b>

*I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.*

Signed by the responsible Minister: Andrea Leadsom Date: 16 October 2015

# Summary: Analysis & Evidence

## Policy Option 1

**Description:** Narrower Definition of Protected Areas, plus commencement of section 4A changes

### FULL ECONOMIC ASSESSMENT

Price Base Year 2015	PV Base Year 2016	Time Period Years 20	Net Benefit (Present Value (PV)) (£m)		
			Low: -16.2	High: -96.8	Best Estimate: -40.0

COSTS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	0	0	1.1	16.2
High	0		6.7	96.8
Best Estimate	0		2.8	40.0

#### Description and scale of key monetised costs by 'main affected groups'

The costs come from the loss of value from gas production prevented by defining some areas as protected net of the avoided costs of discovery, development and administration. They all accrue directly to petroleum licensees (oil and gas companies) though much of the net cost would eventually flow through to the Exchequer through lower taxation receipts and some income would not flow to local communities.

#### Other key non-monetised costs by 'main affected groups'

None.

BENEFITS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0	0	0	0
High	0		0	0
Best Estimate	0		0	0

#### Description and scale of key monetised benefits by 'main affected groups'

Benefits are netted off in arriving at the costs reported above.

#### Other key non-monetised benefits by 'main affected groups'

The environmental benefits from preventing hydraulic fracturing in protected areas has been considered, but not quantified (see impact of policy options, page 8).

#### Key assumptions/sensitivities/risks

#### Discount rate (%)

3.5

Extent of lost oil and gas activity and resultant reduction in level of production relative to the baseline are both uncertain as are the costs of exploration and development and future gas prices. A range is presented above based on different assumptions for gas prices and for the cost per well of complying with the section 4A conditions.

### BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			In scope of OITO?	Measure qualifies as
Costs: 1.98	Benefits: 0.00	Net: 1.98 (cost)	Yes	IN

## Summary: Analysis & Evidence

## Policy Option 2

**Description:** Broader Definition of Protected Areas, with no vertical limit, plus commencement of section 4A changes

### FULL ECONOMIC ASSESSMENT

Price Base Year 2015	PV Base Year 2016	Time Period Years 20	Net Benefit (Present Value (PV)) (£m)		
			Low: -21.3	High: -245.4	Best Estimate: -80.8

COSTS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	0	0	1.5	21.3
High	0		16.9	245.4
Best Estimate	0		5.6	80.8

#### Description and scale of key monetised costs by 'main affected groups'

The costs come from the loss of value from gas production prevented by defining some areas as protected net of the avoided costs of discovery, development and administration. They all accrue directly to petroleum licensees (oil and gas companies) though much of the net cost would eventually flow through to the Exchequer through lower taxation receipts and some income would not flow to local communities.

#### Other key non-monetised costs by 'main affected groups'

None.

BENEFITS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0	0	0	0
High	0		0	0
Best Estimate	0		0	0

#### Description and scale of key monetised benefits by 'main affected groups'

Benefits are netted off in arriving at the costs reported above.

#### Other key non-monetised benefits by 'main affected groups'

The environmental benefits from preventing hydraulic fracturing in protected areas has been considered, but not quantified (see impact of policy options, page 8). Given the wider scope of protected areas, the environmental benefits of Option 2 would be greater than those arising from Option 1.

#### Key assumptions/sensitivities/risks

#### Discount rate (%)

3.5

Extent of lost oil and gas activity and resultant reduction in level of production relative to the baseline are both uncertain as are the costs of exploration and development and future gas prices. A range is presented above based on different assumptions for gas prices and for the cost per well of complying with the section 4A conditions. The broader definition of protected areas compared with Option 1 is set out in the table on page 6.

### BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			In scope of OITO?	Measure qualifies as
Costs: 4.00	Benefits: 0.00	Net: 4.00 (cost)	Yes	IN

# Evidence Base

## Problem under Consideration

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The UK Government has committed to developing its indigenous oil and gas resources including shale gas. Significant progress has been made in establishing a new tax regime and streamlining the regulatory regime to allow exploration for shale gas to begin, for instance, by developing a single application form for environmental permits and reducing permitting times.

Sections 4A and 4B of the Petroleum Act 1998 (“the Act”) were inserted by section 50 of the Infrastructure Act 2015<sup>1</sup> to introduce certain safeguards in relation to hydraulic fracturing, which is a prerequisite for extraction of oil and gas from shale. The assessment of the impact of section 50 of the Infrastructure Act was not included in the overall IA for that Act. Since section 50 has not yet been commenced, the effect of section 4A, which sets out conditions that must be met before a hydraulic fracturing consent can be given in respect of an onshore licence for England and Wales, is considered here together with the effect of the draft regulations prescribing protected areas under section 4B.

Once section 50 of the Infrastructure Act 2015 is commenced, the Petroleum Act 1998 will restrict hydraulic fracturing, as defined in the Act, from underneath the surface to a depth of 1,000 metres anywhere in England and Wales. The Act further stipulates that no hydraulic fracturing can take place within Protected Groundwater Source Areas or Other Protected Areas. These terms were undefined and instead the Act introduces a statutory duty to lay draft regulations by the end of July 2015 defining these protected areas. This IA considers, in particular, the implications of the options that have been considered for defining “protected areas”.

## Rationale for intervention

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Section 4A of the Petroleum Act 1998 (“Onshore hydraulic fracturing: safeguards”) sets out conditions that must be met before a hydraulic fracturing consent can be given in respect of an onshore licence for England and Wales. The measures are intended to mitigate the risk of environmental externalities occurring.

The section 4A conditions ban hydraulic fracturing within protected groundwater source areas and other protected areas. Regulations, which must be made by statutory instrument, are required to specify the descriptions of areas which are “protected groundwater source areas” and the descriptions of areas which are “other protected areas” for the purposes of section 4A of the Act.

Section 4B(6) of the Act requires the Secretary of State to lay a draft of the first regulations under section 4B(4) of that Act before each House of Parliament on or before 31 July 2015.

Preventing hydraulic fracturing in protected areas does not mean that individuals or companies will be able to undertake hydraulic fracturing in other areas in an irresponsible manner. All existing regulations and safety measures will remain in place, and local people will still be able to make their concerns heard and engage with local developments. The following conditions will still apply to any individual or company who would like to exploit oil or gas: Petroleum Exploration and Development Licence; planning permission; permits from the relevant environmental regulator; plans examined and approved by the Health and Safety Executive; drilling consent for drilling or production; and hydraulic fracturing consent, where relevant.

Government believes that shale gas has the potential to provide the UK with greater energy security, growth and jobs. Successful exploration for unconventional resources in other countries, notably the United States, has proved an important source of energy. We know that there are large shale resources in the UK but we do not yet know how much of the unconventional oil and gas in the UK is technically and

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1. The clause that became that section was introduced by an opposition amendment late in the passage of the Infrastructure Bill.

commercially recoverable. There is some potential for shale oil but we have very little understanding of the commercial viability of its development so the focus of this IA is restricted to shale gas.

## **Policy Objective**

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To define “protected groundwater source areas” and “other protected areas”, as will be required by the Petroleum Act 1998 once section 50 of the Infrastructure Act 2015 is commenced. The impact assessment also covers the impacts associated with the other conditions introduced by section 50 of the Infrastructure Act.

## **Options Considered**

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We compare the options for change with a hypothetical **Do-Nothing scenario** which assumes section 50 of the Infrastructure Act 2015 is never commenced and no areas are defined as protected. The other options assume that this section is commenced in autumn 2015 and therefore include the effects of the conditions introduced by sections 4A of the Petroleum Act 1998 and of the definition of protected areas under section 4A of that Act. For clarity, the costs of the section 4A conditions is estimated separately from the effect of defining protected areas.

### **Section 4A changes**

Section 50 of the Infrastructure Act 2015, once commenced, will ensure that the Secretary of State must not issue consent to drill a well unless that well consent contains conditions which among other things will prohibit associated hydraulic fracturing at a depth of less than 1,000 metres and requiring a hydraulic fracturing consent for associated hydraulic fracturing at a depth of 1,000 metres and below.

The conditions include a range of further requirements if an operator is to carry out hydraulic fracturing. These should provide the public with confidence that the shale gas industry is being taken forward in a balanced way. They include environmental impact assessments, groundwater monitoring, community benefits and the 'restrictions in protected areas. They confirm proposals that are already Government policy, carried out voluntarily by industry or part of the regulators' working practice. These reflect existing (best) practice but may nevertheless impose small additional compliance costs.

For example, hydraulic fracturing activity will not be allowed to take place unless an assessment of environmental impacts has been carried out. The Secretary of State will not grant consent for associated hydraulic fracturing unless the environmental impact of the development which includes the relevant well has been taken into account by the local planning authority. The Secretary of State may rely on a notice from the local planning authority, which would state that environmental information has been taken into account before a decision to grant the relevant planning permission is taken. When granting planning permission, planning authorities are already required to confirm that environmental information has been taken into account in any case where an environment statement (part of the Environmental Impact Assessment process) has been submitted.

### **Protected Areas**

In terms of the definition of protected areas, a number of options have been considered involving the spatial extent (i.e. surface) of more or less restricted areas. Consideration has also been given to restricting protected areas vertically (i.e. depth), thus allowing hydraulic fracturing underneath protected areas (for example, in the case of National Parks from outside the National Park (through the use of horizontal drilling), given current planning restrictions on drilling in National Parks).

The preferred option for defining protected areas, **Option 1**, represents a narrower scope in respect of the definition of protected areas and would also introduce a depth limit of 1,200 metres beneath the surface beneath which hydraulic fracturing would be permitted (subject to the usual health, safety and environmental safeguards and obtaining planning and regulatory permissions). An alternative option for

defining protected areas, **Option 2**, represents a broader definition of protected areas, with no vertical limit. These options are compared in the table below:

Preferred option (Option 1)	Scope/Horizontal Extent	Protected Groundwater Source Area <sup>2</sup>	Other Protected Areas
	Vertical Extent	SPZ1 only	National Parks, The Broads, AONBs, World Heritage Sites
Alternative (Option 2)	Scope/Horizontal Extent	SPZ1 + 2 + 3	National Parks, The Broads, Areas of Outstanding Natural Beauty (AONBs), World Heritage Sites, Ramsar Sites, Natura 2000, Sites of Special Scientific Interest (SSSIs)
	Vertical Extent	Unlimited (going all the way down)	Unlimited (going all the way down)

The maps in **Annex A** show the spatial extent of the different areas and how they relate to the two main areas where exploration for and development of shale gas are expected (the Bowland Shale in the north of England and the Weald Basin in south east England).

## Impact of Policy Options

The primary benefits and costs which drive the NPVs in this IA are the direct net costs to business from opportunities forgone relative to the baseline. There are also costs associated with the conditions imposed by section 4A of the Petroleum Act. Those are considered first.

### Section 4A changes

Section 4A introduces a number of conditions which mostly either confirm existing (best) practice or involve relatively small administrative costs to developers (small in comparison with the total gross costs and revenues expected per well). For example, the industry are already committed to carrying out an EIA in all cases where hydraulic fracturing is involved at exploration. In the absence of a detailed assessment, we have estimated that the cost of all of the conditions introduced by section 4A will on average be £50,000 per hydraulically fractured well (in 2015 prices). This estimate is informed by advice from the Oil and Gas Authority taking account of the range of conditions and the lack of detailed knowledge of the likely cost of complying with the various conditions, to the extent they are in practice new requirements (eg monitoring the level of methane in groundwater and emissions of methane into the air). It is assumed that any part of this cost falling on planning authorities or the Health and Safety Executive will be recovered through fees and charges so is treated here as a cost to business (as the measure increases the scope of regulatory burden).

For the number of pads assumed above in the “Do nothing” scenario, the present value of these costs is £29.8 million (ie an NPV of -£29.8 million). As a sensitivity, the average cost has been varied between a low of £25,000 and a high of £100,000 per hydraulically fractured well; the corresponding NPVs are -£14.9 million and -£59.6 million.

2. See *Groundwater protection: Principles and practice (GP3)* (Environment Agency, August 2013, online at [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/297347/LIT\\_7660\\_9a3742.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297347/LIT_7660_9a3742.pdf)). SPZ = Source Protection Zone.

## Protected Areas

### Methodology

Cost to business from the designation of protected areas would arise from the forgone surplus of revenue over costs from the activity that would be lost. The key assumptions are therefore the change in the level of activity, production levels, gas prices and finding and development costs including the costs of getting regulatory approval and planning permission to these activities.

To measure the surplus of revenues over cost from the lost activity, we assess in this IA the cumulative impact of the loss of production caused by the designation of protected areas multiplied by the annual projected mark up of gas prices relative to underlying finding and development costs. The key assumptions are considered in turn below. The assessment starts from a “Do nothing” baseline which assumes no protected areas are designated so hydraulic fracturing would, subject to health, safety, environment and planning restrictions, be possible anywhere in England and Wales. The methodology used here is essentially the same as that adopted in two recent IAs (New Shale-Friendly Model Clauses for Landward Areas<sup>3</sup> and Underground Access Rights clauses in 2014 Infrastructure Bill – impact on oil and gas activities<sup>4</sup>) but the price and present value base years have been moved forward to 2015 and various assumptions have been updated (including on gas prices and development costs).

### (a) Activity Levels

An assessment has been made of the scale of shale gas activity in England and Wales that is plausible (a) in the absence of and (b) with the designation of protected areas.

The level of future shale gas activity is at present extremely uncertain as is the impact of designation of protected areas. It is assumed that activity will pick up quite quickly and reach a plateau level of 6 pads (i.e. shale gas well centres) per year from 2024 onwards. For the central assessment, the number of new shale gas pads whose exploration and subsequent development is assumed to start each year in England and Wales is as follows:

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Do Nothing	0.15	0.15	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.00
Section 4A changes	0.15	0.15	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.00
Protected Areas Option 1	0.15	0.15	1.49	2.23	2.97	3.71	4.46	5.20	5.94	5.94
Protected Areas Option 2	0.14	0.14	1.43	2.14	2.85	3.56	4.28	4.99	5.70	5.70
<b>Change (Section 4A changes)</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
<b>Change (Protected Areas Option 1)</b>	<b>0.00</b>	<b>0.00</b>	<b>-0.02</b>	<b>-0.02</b>	<b>-0.03</b>	<b>-0.04</b>	<b>-0.04</b>	<b>-0.05</b>	<b>-0.06</b>	<b>-0.06</b>
<b>Change (Protected Areas Option 2)</b>	<b>-0.01</b>	<b>-0.01</b>	<b>-0.08</b>	<b>-0.11</b>	<b>-0.15</b>	<b>-0.19</b>	<b>-0.23</b>	<b>-0.26</b>	<b>-0.30</b>	<b>-0.30</b>
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Do Nothing	6.00	6.00	6.00	6.00	6.00	6.00	0.00	0.00	0.00	0.00
Section 4A changes	6.00	6.00	6.00	6.00	6.00	6.00	0.00	0.00	0.00	0.00
Protected Areas Option 1	5.94	5.94	5.94	5.94	5.94	5.94	0.00	0.00	0.00	0.00
Protected Areas Option 2	5.70	5.70	5.70	5.70	5.70	5.70	0.00	0.00	0.00	0.00
<b>Change (Section 4A changes)</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
<b>Change (Protected Areas Option 1)</b>	<b>-0.06</b>	<b>-0.06</b>	<b>-0.06</b>	<b>-0.06</b>	<b>-0.06</b>	<b>-0.06</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
<b>Change (Protected Areas Option 2)</b>	<b>-0.30</b>	<b>-0.30</b>	<b>-0.30</b>	<b>-0.30</b>	<b>-0.30</b>	<b>-0.30</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>

The profile assumed for numbers of pads started each year in the absence of policy change follows (albeit with a year's slippage) the profile adopted for the recent “underground access” impact assessment. This

3. [http://www.legislation.gov.uk/ukia/2014/203/pdfs/ukia\\_20140203\\_en.pdf](http://www.legislation.gov.uk/ukia/2014/203/pdfs/ukia_20140203_en.pdf).

4. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/358553/access\\_rights\\_IA\\_oil\\_and\\_gas.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/358553/access_rights_IA_oil_and_gas.pdf).

assumption is designed to allow for maximum comparability with the earlier impact assessments. It should, therefore, **not** be inferred that activity would actually cease abruptly after 2031. The number of pads assumed to be started per year is not an integral value prior to 2024. In effect, the profile given is a probability weighted average of profiles with different numbers of pads started in each year.

The difference in assumed activity between the “Do nothing” and “Section 4A changes” scenarios, on the one hand, and Protected Areas Option 1, on the other, is very small because existing regulations and planning policies already prevent shale developments in most of the protected areas under consideration through planning guidance (this includes Areas of Outstanding Natural Beauty, World Heritage Sites, National Parks and the Broads).<sup>5</sup> Furthermore, the Environment Agency would not permit drilling in groundwater Source Protection Zone 1 areas, which is the definition for protected groundwater source areas in Option 1. The actual difference in activity (a loss of 1 per cent) is illustrative. The difference for Protected Areas Option 2 is, illustratively, assumed to be 5 per cent, reflecting both the greater areal extent of the protected areas (compare the maps in **Annex A**) and the absence of a vertical limit.

The measures do not apply to Scotland. The Welsh Government have issued a new “direction” to Mineral Planning Authorities to notify the minister of any planning application for unconventional extraction techniques which, we understand, would introduce a de facto moratorium in Wales. The understanding of shale prospectivity in Wales is not as far progressed as that of England, where exploration drilling has already taken place and there are firm plans to hydraulically fracture and test wells. Therefore, the benefits are largely attributable to England in the short term. Furthermore, the Welsh shale prospectivity is almost all outside of Areas of Outstanding Natural Beauty, National Parks and World Heritage Sites. Therefore, the “protected areas” would have very little impact on Welsh shale development. Further consideration of the effects of the options is therefore restricted to England, where the bulk of the potential benefit from hydraulic fracturing is expected.

The benefit from Option 2 would lie in allowing for a greater length of time for remedial action to be taken in the highly unlikely event of a pollution incident affecting groundwater; it would also prohibit hydraulic fracturing under additional categories of other protected area. However, given that the existing regulatory framework already takes a robust risk-based approach to the protection of all these areas, the additional level of protection afforded by Option 2 as compared to Option 1 is considered to be relatively small. We consider that any additional benefit provided by Option 2 is outweighed by its greater cost in terms of reduced activity and economic benefit.

## **(b) Production Levels**

Both the number of wells and the average recovery per well are uncertain in the absence of any current development of shale gas in England and Wales and the extremely limited exploration that has been undertaken to date. We have therefore adopted assumptions based on advice from industry which in turn is informed by their North American experience. Each pad is modelled on the basis of a common assumption of 12 producing wells with an average recovery of 4 billion cubic feet of gas per well. Recovery rates per well vary within and between pads in a given play and between plays and as yet we have no actual experience of the productivity of shale wells in England and Wales so we have had to rely on industry expectations as reported confidentially to DECC (now the Oil and Gas Authority).

The assumptions on numbers of pads and recovery per pad imply total annual production of shale gas of some 6 billion cubic metres (bcm) of gas by 2035 across the whole of England and Wales (and a cumulative total of around 70 bcm from pads started before 2035). That rate is broadly in line with National Grid’s “Slow Progression” scenario<sup>6</sup> but double the estimate of the International Energy Agency in its *World*

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5. See <https://www.gov.uk/government/speeches/planning-for-unconventional-oil-and-gas>.

6. Illustrated in Figure 118 of National Grid’s July 2014 *UK Future Energy Scenarios* publication (<http://www2.nationalgrid.com/uk/industry-information/future-of-energy/future-energy-scenarios/>).



*Economic Outlook 2013*<sup>7</sup> which forecasts UK shale gas production of 3 bcm in 2035. (National Grid's "No Progression" scenario has no successful development.) This estimate of production levels is some way below the rates of production projected in the IoD's May 2013 report *Getting shale gas working*<sup>8</sup> and EY's April 2014 report *Getting Ready for UK Shale Gas*,<sup>9</sup> which reflect higher assumptions on numbers of pads and/or wells per pad, and National Grid's "Gone Green" and "Low Carbon Life" scenarios. In February 2014, Pöyry<sup>10</sup> assumed 100 new wells a year by 2024 spread over about 10 new pads but they did not explicitly report the assumed recovery per well or the implied annual rate of production.

We are therefore using a relatively conservative set of assumptions. The cumulative loss of production from defining protected areas varies between 0.7 bcm (Option 1) and 3.5 bcm (Option 2); the reduction in annual production varies between 0.1 bcm (Option 1) and 0.3 bcm (Option 2).

### **(c) Development Costs**

The timing and level of development costs and the profile of production are informed by confidential advice from industry, but there is uncertainty about these costs and – due to the absence of experience in shale gas exploration and production in England and Wales – they have not been tested and proven yet. Average unit costs for each shale gas pad are estimates by the Oil and Gas Authority based on industry assumptions which are consistent with marginally commercial developments allowing for recovery of the costs of successful and unsuccessful exploration. The implied average unit full-cycle development and production cost for new pads is 59.2p/therm (in 2015 prices). The costs include the costs of exploration, appraisal and development drilling including hydraulic fracturing costs, operating costs including assumed business rate payments and decommissioning costs.

### **(d) Gas Prices**

Gas prices have been assumed to remain constant at 65p/therm in 2015 prices. This level is broadly consistent with the average gas price implied by the central gas price case from DECC's latest published fossil fuel price scenarios.<sup>11</sup> DECC's fossil fuel price scenarios are widely used across Government to assess energy market interventions. It should be noted that, in recent months, European wholesale gas prices have fallen significantly and spot prices are currently (early July 2015) around two thirds of the level assumed here. If that level persisted then it is less likely that there would be a high level of shale gas activity in England and Wales. The cost of the section 4A changes could in such a scenario be material in decisions on whether to explore for or develop shale gas. Against that, the effect of the definition of protected areas would be significantly attenuated.

### **(e) Timing**

Each pad is included in the analysis at the point at which exploration is assumed to start on the basis of the NPV of future revenues minus costs which may extend beyond the assessment period (which has been extended to 2035 given the slow build-up of activity assumed and the long life of such projects, which are expected to last for around 25 years). The 20 year assessment period used to assess the net impact on oil and gas from the policy options is used for consistency with the period used in the two recent IAs referenced above.

### **(f) Administrative Costs**

The savings in administrative costs for HMG depend entirely on the extent of activity lost as a result of designating some areas as protected. Given the scale of cost to industry it is not thought to be

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7. November 2013, page 121; <http://www.worldenergyoutlook.org/>.

8. <http://www.iod.com/influencing/policy-papers/infrastructure/infrastructure-for-business-getting-shale-gas-working>.

9. [http://www.ukoog.org.uk/images/ukoog/pdfs/Getting ready for UK shale2 gas FINAL2022.04.14.pdf](http://www.ukoog.org.uk/images/ukoog/pdfs/Getting_ready_for_UK_shale2_gas_FINAL2022.04.14.pdf).

10. <http://www.poyry.co.uk/news/new-poyry-point-view-uk-shale-gas-where-are-we-now>.

11. <https://www.gov.uk/government/publications/fossil-fuel-price-projections-2014>.

proportionate to value the relatively insignificant incremental administrative saving associated with the reduced activity.

## (g) Carbon Emissions

Flaring of gas at onshore sites in England requires a permit from the Environment Agency and the consent of the Secretary of State under the Energy Act 1976. Government policy is that any flaring should be reduced to the economic minimum. In the Strategic Environmental Assessment carried out for the 14th onshore licensing round, the lifetime level of flaring for unconventional oil and gas was assessed to be 500,000 cubic metres of methane per fractured exploration well. Given the small number of exploration wells expected to be impacted by the options for designation of protected areas we have not attempted to quantify the impact on carbon emissions.

## Summary

The net (undiscounted) benefits of the definition of protected areas are estimated as follows:

$$Net\ Benefit = \sum_{t=1}^{20} ((G_t - D_t) \cdot \frac{1}{100}) \cdot R \cdot \Delta P_t$$

where t is time (years),  $G_t$  is the gas price in pence per therm at time t, D the cost of development and exploration in pence per therm, R is the average discounted gas reserves per project and  $\Delta P_t$  is the change in the number of projects begun in year t as a result of the definition of protected areas where hydraulic fracturing cannot take place. For a single 12 well project started in 2016, the NPV (in 2015 prices in 2016) is £20.5 million, calculated as follows:

$$(65p/therm - 59.2p/therm) / 100 * 366 \text{ million therms} + £50,000 \times 12$$

[366 million therms is the total discounted production from a 12 well pad where each well produces a total of 4 bcf (3.05 bcf discounted) with an average calorific value (BTU/scf) of 1,000. The assumed cost of compliance with the section 4A conditions is included here as an additional term.]

## Net Benefits

For the central case, the time profile of net benefits for the options are as follows:

<b>Net Value (£ million)</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>	<b>2024</b>	<b>2025</b>
Do Nothing	3.2	3.2	31.7	47.5	63.4	79.2	95.1	110.9	126.8	126.8
Section 4A changes	3.1	3.1	30.8	46.2	61.6	77.0	92.4	107.8	123.2	123.2
Protected Areas Option 1	3.0	3.0	30.5	45.7	61.0	76.2	91.5	106.7	121.9	121.9
Protected Areas Option 2	2.9	2.9	29.3	43.9	58.5	73.1	87.8	102.4	117.0	117.0
<b>Change (Section 4A changes)</b>	<b>-0.1</b>	<b>-0.1</b>	<b>-0.9</b>	<b>-1.4</b>	<b>-1.8</b>	<b>-2.3</b>	<b>-2.7</b>	<b>-3.2</b>	<b>-3.6</b>	<b>-3.6</b>
<b>Change (Protected Areas Option 1)</b>	<b>0.0</b>	<b>0.0</b>	<b>-0.3</b>	<b>-0.5</b>	<b>-0.6</b>	<b>-0.8</b>	<b>-0.9</b>	<b>-1.1</b>	<b>-1.2</b>	<b>-1.2</b>
<b>Change (Protected Areas Option 2)</b>	<b>-0.2</b>	<b>-0.2</b>	<b>-1.5</b>	<b>-2.3</b>	<b>-3.1</b>	<b>-3.8</b>	<b>-4.6</b>	<b>-5.4</b>	<b>-6.2</b>	<b>-6.2</b>
<b>Net Value (£ million)</b>	<b>2026</b>	<b>2027</b>	<b>2028</b>	<b>2029</b>	<b>2030</b>	<b>2031</b>	<b>2032</b>	<b>2033</b>	<b>2034</b>	<b>2035</b>
Do Nothing	126.8	126.8	126.8	126.8	126.8	126.8	0.0	0.0	0.0	0.0
Section 4A changes	123.2	123.2	123.2	123.2	123.2	123.2	0.0	0.0	0.0	0.0
Protected Areas Option 1	121.9	121.9	121.9	121.9	121.9	121.9	0.0	0.0	0.0	0.0
Protected Areas Option 2	117.0	117.0	117.0	117.0	117.0	117.0	0.0	0.0	0.0	0.0
<b>Change (Section 4A changes)</b>	<b>-3.6</b>	<b>-3.6</b>	<b>-3.6</b>	<b>-3.6</b>	<b>-3.6</b>	<b>-3.6</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Change (Protected Areas Option 1)</b>	<b>-1.2</b>	<b>-1.2</b>	<b>-1.2</b>	<b>-1.2</b>	<b>-1.2</b>	<b>-1.2</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Change (Protected Areas Option 2)</b>	<b>-6.2</b>	<b>-6.2</b>	<b>-6.2</b>	<b>-6.2</b>	<b>-6.2</b>	<b>-6.2</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>

Based on the assumptions described above, the NPV of selecting the favoured option rather than the do nothing option is -£40.0 million (in 2015 prices). This and subsequent NPVs *include* the cost of the section 4A changes.

Extreme uncertainty attaches to the key parameters underlying this estimate; most if not all of the assumptions are subject to very wide margins of error. The estimates indicate a large volume of hydrocarbons but not enough is yet known to estimate how much gas or oil may be ultimately produced. Exploratory drilling and fracturing is required before these factors can be estimated. The UK shale gas industry is in its infancy and it is far from clear how much production will occur and at what cost. As such the impact on gas prices is itself highly uncertain. It is possible that shale gas will not prove to be commercially exploitable in England and Wales (especially if gas prices were to remain low) but equally it is possible that gas prices will be much higher than assumed in the central case or the average well might be much more productive or less costly. For illustrative purposes, low and high gas prices are used below to show the possible outcomes under alternative assumptions regarding one of the key parameters. The lower and higher gas price assumptions are intended to give a feel for how sensitive the analysis to this parameter. It should be noted that, unless costs fell, development of shale gas would not be commercially attractive at gas prices much below the low level used illustratively here. These sensitivities are on top of the low/high sensitivity to the cost per well of the section 4A changes,

For the lower gas price sensitivity case (60p/therm in 2015 prices), the time profile of net benefits for the options are as follows:

<b>Net Value (£ million)</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>	<b>2024</b>	<b>2025</b>
Do Nothing	0.4	0.4	4.3	6.4	8.6	10.7	12.8	15.0	17.1	17.1
Section 4A changes	0.4	0.4	3.8	5.7	7.7	9.6	11.5	13.4	15.3	15.3
Protected Areas Option 1	0.4	0.4	3.8	5.7	7.6	9.5	11.4	13.3	15.2	15.2
Protected Areas Option 2	0.4	0.4	3.6	5.5	7.3	9.1	10.9	12.7	14.5	14.5
<b>Change (Section 4A changes)</b>	<b>0.0</b>	<b>0.0</b>	<b>-0.5</b>	<b>-0.7</b>	<b>-0.9</b>	<b>-1.1</b>	<b>-1.4</b>	<b>-1.6</b>	<b>-1.8</b>	<b>-1.8</b>
<b>Change (Protected Areas Option 1)</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>-0.1</b>	<b>-0.1</b>	<b>-0.1</b>	<b>-0.1</b>	<b>-0.1</b>	<b>-0.2</b>	<b>-0.2</b>
<b>Change (Protected Areas Option 2)</b>	<b>0.0</b>	<b>0.0</b>	<b>-0.2</b>	<b>-0.3</b>	<b>-0.4</b>	<b>-0.5</b>	<b>-0.6</b>	<b>-0.7</b>	<b>-0.8</b>	<b>-0.8</b>

<b>Net Value (£ million)</b>	<b>2026</b>	<b>2027</b>	<b>2028</b>	<b>2029</b>	<b>2030</b>	<b>2031</b>	<b>2032</b>	<b>2033</b>	<b>2034</b>	<b>2035</b>
Do Nothing	17.1	17.1	17.1	17.1	17.1	17.1	0.0	0.0	0.0	0.0
Section 4A changes	15.3	15.3	15.3	15.3	15.3	15.3	0.0	0.0	0.0	0.0
Protected Areas Option 1	15.2	15.2	15.2	15.2	15.2	15.2	0.0	0.0	0.0	0.0
Protected Areas Option 2	14.5	14.5	14.5	14.5	14.5	14.5	0.0	0.0	0.0	0.0
<b>Change (Section 4A changes)</b>	<b>-1.8</b>	<b>-1.8</b>	<b>-1.8</b>	<b>-1.8</b>	<b>-1.8</b>	<b>-1.8</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Change (Protected Areas Option 1)</b>	<b>-0.2</b>	<b>-0.2</b>	<b>-0.2</b>	<b>-0.2</b>	<b>-0.2</b>	<b>-0.2</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Change (Protected Areas Option 2)</b>	<b>-0.8</b>	<b>-0.8</b>	<b>-0.8</b>	<b>-0.8</b>	<b>-0.8</b>	<b>-0.8</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>

Based on the assumptions described above, in the low gas price sensitivity case the NPV of selecting the favoured option rather than the do nothing option is -£16.2 million (in 2015 prices).

For the higher gas price sensitivity case (80p/therm in 2015 prices), the time profile of net benefits for the options are as follows:

<b>Net Value (£ million)</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>	<b>2024</b>	<b>2025</b>
Do Nothing	11.4	11.4	113.9	170.9	227.9	284.8	341.8	398.8	455.7	455.7
Section 4A changes	11.2	11.2	112.1	168.2	224.3	280.3	336.4	392.5	448.5	448.5
Protected Areas Option 1	11.1	11.1	111.0	166.5	222.0	277.5	333.0	388.5	444.1	444.1
Protected Areas Option 2	10.7	10.7	106.5	159.8	213.1	266.3	319.6	372.8	426.1	426.1
<b>Change (Section 4A changes)</b>	<b>-0.2</b>	<b>-0.2</b>	<b>-1.8</b>	<b>-2.7</b>	<b>-3.6</b>	<b>-4.5</b>	<b>-5.4</b>	<b>-6.3</b>	<b>-7.2</b>	<b>-7.2</b>
<b>Change (Protected Areas Option 1)</b>	<b>-0.1</b>	<b>-0.1</b>	<b>-1.1</b>	<b>-1.7</b>	<b>-2.2</b>	<b>-2.8</b>	<b>-3.4</b>	<b>-3.9</b>	<b>-4.5</b>	<b>-4.5</b>
<b>Change (Protected Areas Option 2)</b>	<b>-0.6</b>	<b>-0.6</b>	<b>-5.6</b>	<b>-8.4</b>	<b>-11.2</b>	<b>-14.0</b>	<b>-16.8</b>	<b>-19.6</b>	<b>-22.4</b>	<b>-22.4</b>

<b>Net Value (£ million)</b>	<b>2026</b>	<b>2027</b>	<b>2028</b>	<b>2029</b>	<b>2030</b>	<b>2031</b>	<b>2032</b>	<b>2033</b>	<b>2034</b>	<b>2035</b>
Do Nothing	455.7	455.7	455.7	455.7	455.7	455.7	0.0	0.0	0.0	0.0
Section 4A changes	448.5	448.5	448.5	448.5	448.5	448.5	0.0	0.0	0.0	0.0
Protected Areas Option 1	444.1	444.1	444.1	444.1	444.1	444.1	0.0	0.0	0.0	0.0
Protected Areas Option 2	426.1	426.1	426.1	426.1	426.1	426.1	0.0	0.0	0.0	0.0
<b>Change (Section 4A changes)</b>	<b>-7.2</b>	<b>-7.2</b>	<b>-7.2</b>	<b>-7.2</b>	<b>-7.2</b>	<b>-7.2</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Change (Protected Areas Option 1)</b>	<b>-4.5</b>	<b>-4.5</b>	<b>-4.5</b>	<b>-4.5</b>	<b>-4.5</b>	<b>-4.5</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Change (Protected Areas Option 2)</b>	<b>-22.4</b>	<b>-22.4</b>	<b>-22.4</b>	<b>-22.4</b>	<b>-22.4</b>	<b>-22.4</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>

Based on the assumptions described above, in the high gas price sensitivity case the NPV of selecting the favoured option rather than the do nothing option is -£96.8 million (in 2015 prices).

The NPVs and average annual net benefits under the options are summarised as follows:

	<b>Annual Average Benefit</b>		<b>Annual Average Benefit</b>		<b>Annual Average Benefit</b>	
	<b>NPV</b>	<b>(Cost)</b>	<b>NPV</b>	<b>(Cost)</b>	<b>NPV</b>	<b>(Cost)</b>
	<b>(£ million)</b>		<b>(£ million)</b>		<b>(£ million)</b>	
	<b>Low</b>		<b>Central</b>		<b>High</b>	
<b>Section 4A changes</b>	-14.9	-1.0	-29.8	-2.1	-59.6	-4.1
<b>Protected Areas Option 1</b>	-1.3	-0.1	-10.2	-0.7	-37.2	-2.6
<b>Protected Areas Option 2</b>	-20.0	-1.4	-70.6	-4.9	-208.3	-14.4
<b>Total</b>						
<b>Protected Areas Option 1</b>	-16.2	-1.1	-40.0	-2.8	-96.8	-6.7
<b>Protected Areas Option 2</b>	-21.3	-1.5	-80.8	-5.6	-245.4	-16.9

## **Rationale and evidence that justify the level of analysis used in the IA**

The effects of the policy options being considered have a large range of uncertainty. All options would permit exploration for and development of shale gas. However, there are uncertainties about the value of the activity, the nature and scale of the hydrocarbon resource and finding and development costs as stated above. The focus in sensitivity analysis has been on future gas prices. Changes to assumptions on average reserves per well and costs per well could also have been considered but the range of net benefits presented is thought to be wide enough to bracket the likely true impact of the measure. The assumptions on the costs of compliance with the section 4A conditions and the impact on activity levels of the definition of protected areas are illustrative but thought to be indicative of the likely order of magnitude.

## One-in, two-out

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The EANCB related to oil and gas activity has been assessed over the 20 year period 2016–2035 which is the period covered by the NPVs of the various options. Apart from the unquantified administrative benefits to Government, all of the monetary costs and benefits of the policy options fall to business; the ones being counted result directly from the intervention since it is the designation of protected areas that will enable commercial activity elsewhere. The costs and benefits do not include indirect effects such as those on the oil and gas supply chain. Any environmental effects are indirect.

The EANCB has been derived using the EANCB calculator with input annual net benefits and costs calculated as described above based on the preferred policy option for designation of protected areas (Option 1). **This measure falls in scope of OITO and the positive EANCB classifies the measure as an IN. The value of this IN for this policy is £1.98 million (EANCB, 2009 prices).**

## SMBA

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The exact number of small or micro-businesses (defined as having up to 49 FTE and 10 FTE employees respectively, as per BIS Better Regulation Framework Manual) that will be active in the UK shale gas industry or likely to enter the market in coming years is unknown. However, both types of business are currently active in onshore oil and gas exploration and production in England and Wales. There are currently fewer than 30 groups of companies operating onshore licences.<sup>12</sup> Some of these are likely to be small businesses in terms of direct employment; a handful are thought to be micro-businesses in terms of direct employment. Small or micro-businesses may also be non-operator licensees. Hydraulic fracturing is not likely to be undertaken by the smaller companies or, if they are involved, it would probably be as co-venturers. Small and micro-businesses are no more likely than larger businesses to be affected by the policy changes. There are frequent changes of licensee including as a consequence of a lack of activity by current licensees who consequently have to relinquish their acreage so the current structure of the industry may not be reflective of its composition over future decades, especially if a significant level of hydraulic fracturing is seen in practise.

In defining protected areas where hydraulic fracturing cannot be undertaken, the Regulations will reinforce the existing regulatory regime and ensure that the development of shale gas proceeds in a safe and environmentally sound way. Given the intended purpose of the measures, the Government does not believe there is any rationale for exempting businesses or developments of a certain size i.e. allowing development by small or micro-businesses in protected areas or exempting them from the other section 4A conditions. The environmental risks being mitigated are not proportionate to the size of the business or the number of employees undertaking development activity. The administrative burden on business as a result of the measures is expected to be very small and therefore very little prospect of a disproportionate impact on small or micro-businesses in this respect.

## Wider impacts

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All significant oil and gas operations, such as drilling, hydraulic fracturing or production, require planning permission and are subject to operational regulation by the relevant Environmental Regulator (i.e. the Environment Agency or Natural Resources Wales, as the case may be). When commenced, section 50 of the Infrastructure Act 2015 will amend the Petroleum Act 1998 so that the Secretary of State cannot issue consent for associated hydraulic fracturing activity unless the environmental impact of the development which includes the relevant well has been taken into account by the local planning authority. Planning permission will be granted only where the proposed activity is acceptable in terms of land use planning, and the conduct of permitted operations will have to meet the environmental requirements specified by the Environmental Regulator.

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12. See <https://itportal.decc.gov.uk/eng/fox>.

DECC conducted a strategic environmental assessment on the potential environmental effects of the activities which might be consented subsequent to the issue of new licences,<sup>13</sup> which was published for public consultation (which closed on 28 March 2014). The results of the assessment, and the views received in the consultation, were considered before the decision was taken to launch a new onshore licensing round.<sup>14</sup>

A September 2013 report by Professor David MacKay and Dr Tim Stone<sup>15</sup> concluded that we can develop shale and keep emissions low – shale emissions are likely to be lower than the liquefied natural gas it is likely to replace. In addition, a report published in June 2014 by Public Health England<sup>16</sup> concluded that “currently available evidence indicates that the potential risks to public health in the vicinity of shale gas extraction sites will be low if shale gas extraction is properly run and regulated”. Further to this, in 2012 the Royal Academy of Engineering and the Royal Society conducted an independent review of the scientific and engineering evidence on the risks associated with hydraulic fracturing for shale gas.<sup>17</sup> They concluded that the risks can be managed effectively in the UK, provided that operational best practices are implemented and enforced through regulation.

There are robust regulations in place to ensure on-site safety, prevent water contamination and mitigate seismic activity and air pollution. The proposed policy would not change any of these existing requirements.

The relatively small volumes of gas not produced as a result of the chosen policy option are assumed to be replaced by imports. Consequences for security of supply and energy prices have not been quantified as they are judged to be second order. With no material effect on UK gas demand there should be no significant impact on UK carbon dioxide emissions.

## **Summary and preferred option with description of implementation plan**

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The government’s preferred option for defining protected areas is Option 1 since it affords an enhanced level of protection to these areas in a manner that is consistent with the Government’s wider energy security and economic policy objectives and minimises the impact on business. This is the option with the highest NPV (ie lowest NPC). A broader definition of protected areas and the omission of a vertical extent to their definition would be feasible but is thought not to provide benefits from the additional protection afforded commensurate with the associated economic costs.

Implementation will involve laying before both Houses of Parliament, by 31 July 2015, a Statutory Instrument under section 4B of the Petroleum Act 1998 to define “protected groundwater source areas” and (b) the descriptions of areas which are “other protected areas”. In addition, a commencement order will commence section 50 of the Infrastructure Act 2015 which will introduce the conditions set out in section 4A of the Petroleum Act 1998.

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13. *Strategic Environmental Assessment for further onshore oil and gas licensing: environmental report*, December 2013, available online at <https://www.gov.uk/government/consultations/environmental-report-for-further-onshore-oil-and-gas-licensing>.

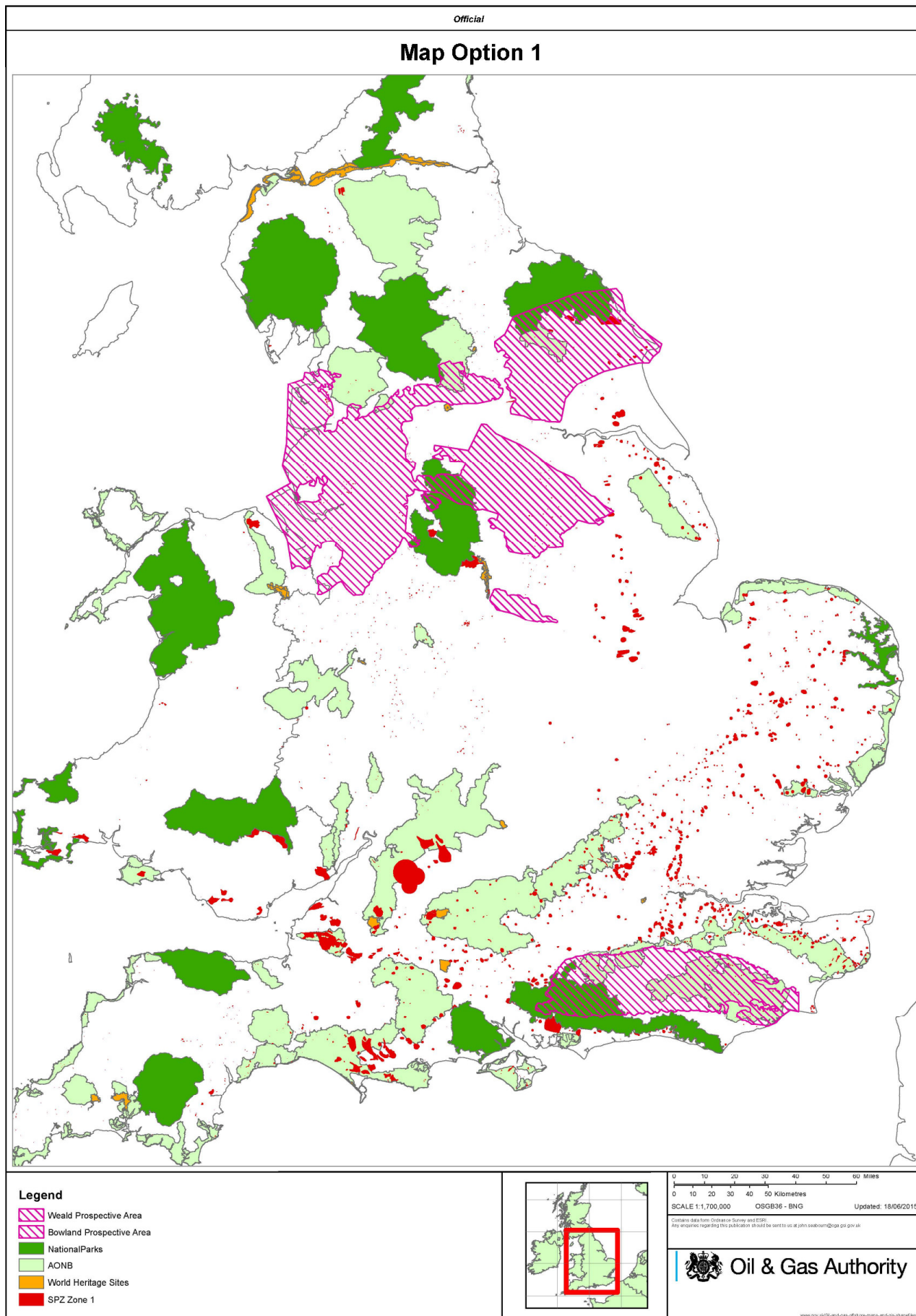
14. See <https://www.gov.uk/government/speeches/outcome-of-the-strategic-environmental-assessment> and <https://www.gov.uk/government/news/new-onshore-licensing-round-opens>.

15. See <https://www.gov.uk/government/publications/potential-greenhouse-gas-emissions-associated-with-shale-gas-production-and-use>.

16. See <http://www.hpa.org.uk/Publications/Environment/PHECRCEReportSeries/PHECRCE009/>.

17. See <https://royalsociety.org/~media/policy/projects/shale-gas-extraction/2012-06-28-shale-gas.pdf>.

# Annex A





# Annex A

