



HSE

Agency opinion on the Annex 15 dossier proposing restrictions on

Lead in Ammunition

**UK REACH AGENCY:
ukreach.clp@hse.gov.uk**

DATE: 11th October 2023

Table of Contents

1. Basis for the proposal	4
2. Proposed restriction	7
2.1 Alternatives to a REACH restriction	16
3. Procedure for adoption of the opinion	19
4. Opinion of the Agency	27
4.1 Risk Assessment	27
4.1.1 Environment.....	27
4.1.2 Human health	38
4.1.3 Conclusion on risk	48
4.2 Rationale for the scope of the proposed options.....	50
4.2.1 Overview of the options that have been considered	51
4.2.2 Rationale for modifying restriction options	56
4.2.5 Further information about the proposed restriction	57
4.3 Justification for action.....	58
4.4 Socioeconomic/Impact Assessment- summary.....	59
4.4.1 Baseline	59
4.4.2 Costs	61
4.4.5 Benefits.....	74
4.4.6 Proportionality.....	80
4.4.7 Summary statistics.....	82
4.5 Practicality and monitorability.....	83
4.6 Potential unintended consequences	85
4.7 Assumptions, uncertainties and sensitivities	86
4.7.1 Uncertainties related to the risk assessment	86
4.7.2 Sensitivities related to the socio-economic analysis	88
5 References.....	93
Further information	97
Annex 1: List of acronyms	98
Annex II: List of definitions	100

EXECUTIVE SUMMARY

The Health and Safety Executive (as the Agency for UK REACH), with support from the Environment Agency, has assessed the risks to both human health and the environment from lead in ammunition. This document summarises the scientific evidence base and technical detail available in the Background Document and communicates the key recommendations of the Agency. It describes:

- the hazards of lead
- the main exposure pathways relevant to lead ammunition used for live quarry shooting and outdoor target shooting
- risk characterisation to determine if lead ammunition poses a risk to the environment and/or human health that is not adequately controlled
- the development of recommended risk management options to address those risks
- a socioeconomic assessment that analyses the potential costs and benefits on both the use and restriction of lead ammunition.

The Agency for UK REACH concludes that:

- for **the environment** there are risks that are not adequately controlled for lead shot (primary and secondary exposure), lead bullets (secondary exposure) and airgun ammunition (primary and secondary exposure)
- amongst **consumers of high volumes of game meat** that has been shot with lead ammunition (shot or bullets), there is a risk to the health of vulnerable people (young children and women of child-bearing age) that is not adequately controlled.

Therefore, the Agency is recommending measures to restrict the use and placing on the market of some types of lead ammunition.

In considering possible options to address these risks, the Agency has considered the appropriateness of the proposed restrictions: their effectiveness, practicality, monitorability and enforceability, examining also the possibility of non-UK REACH options (such as voluntary agreements). As part of this process, the Agency engaged with the REACH Independent Scientific Expert Pool (RISEP) who provided scrutiny and challenge for this opinion.

AGENCY OPINION ON A PROPOSAL FOR A RESTRICTION

1. Basis for the proposal

Request/scope for restriction:

On 29 April 2021, the Health and Safety Executive (HSE), as the Agency for UK REACH, received a request under Article 69(1) of UK REACH from the Secretary of State for the Department of Environment, Food & Rural Affairs, with the agreement of the Scottish Government and the Welsh Government, to prepare an Annex 15 restriction dossier assessing risks from lead ammunition. The basis of the request was that:

‘The use of lead in ammunition raises concerns to both human health and the environment.

The harm of lead ammunition to wildfowl is of particular concern – poisoning from ingesting lead ammunition causes long-term suffering and slow painful deaths for animals.

The health of humans, particularly children, may also be adversely affected from eating meat killed with lead ammunition.

Current domestic regulations partially restrict the use of lead shot.

- In England and Wales, the use of lead shot is prohibited:
 - on all foreshores,
 - in or over specified Sites of Special Scientific Interest (SSSIs) (predominantly wetlands) and
 - for the shooting of all ducks, geese and swans, coots and moorhen.
- In Scotland, the use of lead shot for the purpose of shooting with a shotgun is restricted over any wetland (as defined by the RAMSAR Convention).

Evidence from testing shot water birds for sale at game dealers suggests compliance with these current domestic regulations is low.

For the reasons set out above, the Secretary of State considers that the use of lead in ammunition poses a risk to human health and the environment that is not adequately controlled and needs to be addressed’.

The Secretary of State, therefore, requested that HSE prepare an Annex 15 restriction dossier in respect of these risks and to consider the need for further measures, beyond those already in place.

Military, police and other non-civilian uses were excluded from the scope of this request, as were indoor uses (such as at indoor firing ranges) and lead-containing propellants.

The Annex 15 dossier was published by the Agency as part of the first public consultation (HSE, 2022). Since then, it has been updated and refined into what is known as the *Background Document to the Agency Opinion* (hereafter, “Background Document”). This Background Document underpins the Opinion. Where further detail is required, it can typically be found in the Background Document (HSE, 2023), and is referenced as such.

Background:

The hazards and risks posed by lead to both human health and the environment are generally well understood. Legally binding risk management measures are already in place in the UK to reduce some of these risks from the use of lead in ammunition. England, Scotland and Wales have already enacted a prohibition on the use of lead shot over wetlands in response to the African-Eurasian Waterbird Agreement. Prohibitions were introduced between 1999 and 2004 to protect waterbirds from the impact of poisoning by lead shot, but each varies slightly in the definitions used and its application.

Additionally, the risk of lead ammunition to wildlife is recognised at an international level. The UK is a contracting party to the United Nations Environment (UNEP) Convention on Migratory Species (CMS). As part of this, the Conference of the Parties to CMS adopted the Guidelines to Prevent the Risk of Poisoning to Migratory Birds through Resolution 11.15 (Rev.COP13), which includes the recommendation to “Phase-out the use of lead ammunition across all habitats (wetland and terrestrial) with non-toxic alternatives”, and in order to “... reduce problems with monitoring, compliance and enforcement such processes should not be partially restrictive”.

The risks from the use of lead ammunition in England have been considered previously. In 2010, the Lead Ammunition Group (LAG) was established by the Department for Environment, Food & Rural Affairs (Defra) and the Food Standards Agency (FSA) to evaluate the published scientific evidence of the impact in England of lead ammunition on human health, wildlife, the environment generally and on livestock, and to propose possible mitigation for the risks identified. LAG included key stakeholders and experts from the gun and ammunition trade, game dealers, landowners, animal welfare and conservation organisations, human health, environmental health and sports shooting organisations. In the 2015 report (LAG, 2015a), the LAG concluded that an eventual phase-out of lead ammunition would be the only effective way to address the risks to wildlife and human health. However, prior to the finalisation of its work, members representing the Gun Trade Association (GTA), the Game and Wildlife Conservation Trust, the National Game Dealers Association, the Country Land and Business Association and the Countryside Alliance left LAG as they did not support the conclusions outlined in the LAG report.

The risks from lead in ammunition are also being considered under REACH in the European Union (EU). An EU REACH restriction on the use of lead shot in wetlands came into force on 15 February 2023. A proposed restriction on the use of lead ammunition in all habitats has passed all the European Chemicals Agency (ECHA)

scrutiny stages and is now being considered by the European Commission. Under the Northern Ireland Protocol and the Windsor Framework, EU REACH continues to regulate the Northern Ireland market and so the EU restriction will apply in Northern Ireland. This opinion, therefore, only considers the position for Great Britain (GB).

Throughout this opinion and the Background Document, the Agency¹ has extensively referenced the work done by LAG and by ECHA on EU REACH restrictions. Since the UK was a member of the EU when the technical documents to support the EU wetlands' restriction proposal were drafted, the EU dossier includes data from the UK (and therefore GB). The Agency considers that data which LAG and/or ECHA determined to be reliable are of a sufficient standard for inclusion in this assessment without duplicative detailed review and analysis being necessary.

The Agency has identified several different uses of lead ammunition for the purposes of this restriction proposal, based on technical function and operational conditions (table 1).

¹ Under Article 2B of UK REACH, HSE (as the Agency for UK REACH) obtained the advice of the Environment Agency as part of preparing this dossier. This advice has been used in the assessment of exposure via the environment and risk to the environment from lead in ammunition. The Environment Agency's advice has also been used by HSE in the assessment of the socioeconomic impact and options for restriction. When providing this advice to the Agency, the Environment Agency collaborated with the environmental regulators in Scotland and Wales.

Table 1 - Uses and proposed restriction action

	Use #	Use title	Proposed action
Live quarry shooting (LQS)	1	Live quarry shooting with shot	Restriction on the placing on the market and use
	2	Live quarry shooting with bullets	No recommendation in this document (awaiting further information from public consultation)
	3	Live quarry shooting with airgun ammunition	No action
Outdoor target shooting (TS)	4	Outdoor target shooting with shot	Restriction on the placing on the market and use, with a derogation for individual athletes as identified by the appropriate sporting body
	5	Outdoor target shooting with bullets	Restriction on the use with a derogation for use at certain sites
	6	Outdoor target shooting with airgun ammunition	No action

2. Proposed restriction

This restriction proposal aims to identify the risks posed by the various uses of lead ammunition and to recommend measures to address these where appropriate. The Agency highlights that this restriction proposal does **not** amount to a complete prohibition on live quarry shooting or target shooting in GB.

The Agency initially identified several restriction options for each of the uses identified above (a 'long-list'), as detailed in the Annex 15 dossier that was published in May 2022 (HSE, 2022). From this 'long-list', the Agency selected those options that it considered the most feasible and impactful, i.e., those considered to reduce or eliminate the risks identified for both the environment and human health (the 'shortlist'). An analysis of each of the options on the shortlist was undertaken, and those considered to be effective, practical (fully or partially), monitorable and enforceable were taken forward for an assessment of the socio-economic impacts. Further information is provided in section 4.2 and in the Background Document (HSE, 2022).

As a result of the analysis, the Agency is proposing:

Lead shot (Use 1 and 4)

- **A restriction on the placing on the market and use of lead shot, with a derogation for individual athletes involved in target shooting, as identified by the appropriate sporting body**

Risks to the environment have been identified for the use of lead shot in both live quarry shooting and target shooting. An additional human health risk has been identified for live quarry shooting.

The Agency considers that a restriction on the placing on the market and use is the only realistic way to:

- limit the amount of lead entering the environment; or
- eliminate the risk to humans from ingestion of shot-derived lead in game meat

when lead shot is used for live quarry shooting.

When used for target shooting, lead shot will remain on the surface of the ground where there is a risk of primary poisoning to birds and livestock unless it is immediately collected, which is not considered practical based on information received from ranges during the public consultation on the Annex 15 dossier (HSE, 2022). Similarly, risk management measures are not available at most ranges to manage the risks to soil and to livestock via secondary poisoning from target shooting.

The most effective risk management option is prohibition on the placing on the market and use of lead shot.

By restricting the placing on the market of lead shot for all uses (i.e., both live quarry shooting and target shooting), the effectiveness and compliance of this restriction is increased and subsequent enforcement simplified.

Alternatives to lead shot, such as steel shot, are already available on the GB market and some shooters already use these. Several UK shooting and rural organisations have voluntarily committed to the use of alternatives to lead shot for live quarry shooting by 2025.

The Agency is aware that the use of lead shot is specified for international competitions in some outdoor target shooting disciplines. A derogation is proposed to allow individual athletes as identified by the appropriate sporting body to continue to train and compete with lead shot, and suppliers to continue sales of lead shot to these identified athletes.

As emissions of lead shot would continue under this derogation, it would not be fully effective at removing all the environmental risks identified. However, the socioeconomic assessment indicates that this option is more appropriate and cost-effective than a full prohibition.

Lead bullets (Use 5)

- **A restriction on the use of lead bullets for outdoor target shooting with a derogation for use at ranges with appropriate risk management measures in place**

A risk for the environment that is not adequately controlled has been identified for outdoor target shooting with lead bullets. Given that industry-recognised risk management measures are available, the Agency considers that appropriate implementation of such measures would minimise the risk to acceptable levels. At present many, but not all, sites implement appropriate risk management measures. The Agency is, therefore, proposing a restriction on outdoor target shooting with lead bullets, albeit with a derogation to allow the use of lead bullets at sites which can demonstrate appropriate risk management measures are in place.

The derogation will only apply at outdoor target shooting sites where:

- the site ensures that appropriate action is being taken to reduce the identified risks to the environment, so far as is reasonably practicable, and there is documented evidence which can be made available to an enforcing authority
- notification has been made to the appropriate enforcing authority declaring that they are taking appropriate action to reduce the identified risks to the environment, so far as is reasonably practicable.

A list of notified sites will be made available publicly.

The actions required to reduce the risks to the environment may include appropriate de-leading of ranges, as required by the National Rifle Association (NRA) Range Design and Safety Handbook (NRA, 2022) for the safety of shooters. This measure may be sufficient to address the risks to the environment for a given site, and information received during the first public consultation indicated that most outdoor shooting ranges already follow the Handbook guidance. Hence, it is expected that the use of lead bullets would be able to continue at these ranges.

The Environment Agency also intends to work with the relevant shooting organisations, helping to amend their range guidance to better consider the identified environmental risks.

Placing on the market of lead bullets

A restriction on the placing on the market of lead bullets for use in outdoor target-shooting was not one of the considered options, since:

- these bullets will remain available for indoor target shooting (which remains out of scope of this restriction proposal); and
- it would be impractical to suitably enforce any restriction.

This proposed restriction applies to both large calibre and small calibre bullets. Due to the differences in the availability of alternatives for some specific bullet calibres, and based on feedback from the GTA, the Agency has opted for the following definitions:

- Large calibre (LC) bullets are those having bullet diameter greater than or equal to 6.5 mm
- Small calibre (SC) bullets are those having a bullet diameter less than 6.5 mm.

The Agency acknowledges that these are a departure from the more widely recognised definitions.

Note for lead concentration in ammunition subject to restriction

The proposed restrictions will apply to ammunition with a concentration of equal to or greater than 1 % w/w lead

The proposed concentration limit of 1 % w/w has been chosen to be identical to the concentration limit used in the existing prohibitions on the use of lead shot over wetlands enacted by England, Scotland and Wales. The Agency considers, therefore, that this limit is achievable by manufacturers, whilst still allowing alternatives to be used that might contain low levels of lead as an impurity.

Lead bullets (Use 2)

- **No restriction** is proposed at this time on the placing on the market or use of lead bullets for live quarry shooting

A risk that is not adequately controlled has been identified for live quarry shooting with lead bullets (for both the environment and human health). There are no realistic ways to limit the amount of lead entering the environment from this use or to eliminate the risk to humans from ingestion of ammunition-derived lead when lead bullets are used for live quarry shooting. The most effective risk management option, therefore, would be a prohibition on the placing on the market and use of lead bullets for live quarry shooting.

However, the Agency has been unable to sufficiently quantify the benefits of restricting this use and has not been able to explicitly demonstrate the proportionality of a restriction. The overall cost of implementing a restriction is expected to be low (over a 20-year period), hence the level of benefit required to achieve proportionality would also be low. The Agency will seek more information on the monetisation of benefits for this use during the public consultation before reaching a final opinion on this use.

Unlike the use of lead shot, where a restriction on the placing on the market is proposed for both target shooting and live quarry shooting (Uses 1 and 4), lead bullets will still be available for lawful purchase for outdoor target shooting (Use 5) on sites that meet the derogation criteria. This may create challenges regarding the enforceability of any restriction on lead bullets in relation to live quarry shooting. At this stage, the Agency is unable to determine whether and to what extent lead bullets that remain available for target shooting would continue to be purchased for target

shooting but actually used for live quarry shooting (which would be unlawful in the event that a restriction is implemented).

Such an outcome would undermine the effectiveness of a restriction on the placing on the market of lead bullets for live quarry shooting.

It is to be noted that the Agency is aware of:

- the legal requirement to use expanding ammunition for deer hunting
- the legal requirement for bullets used for shooting live quarry to have sufficient muzzle energy (but not necessarily be expanding), and
- the changes to the Policing and Crime Act (2017), which allows possession of expanding ammunition for rifles.

However, the interactions between these are complex and will require further investigation during the public consultation period.

There is an additional practical concern regarding a restriction on live quarry shooting with lead bullets. It is expected that shooters pursuing live quarry will need to both 'zero' their rifles, and practice, typically on shooting ranges, to ensure accuracy when shooting. Currently, non-lead bullets are not permitted to be used on some ranges; this is primarily due to concerns around safety and damage to infrastructure, the possible extent of which is currently unknown. This might make it difficult for shooters to practice or zero their rifles before engaging quarry, resulting in undesirable outcomes, e.g., missed shots, wounding live quarry without killing.

The Agency does not, in light of these considerations, propose to restrict the placing on the market or the use of lead bullets for live quarry shooting at this time. However, work is continuing to attempt to resolve some of the above uncertainties. In particular, the Agency will consider any further information received during the second public consultation on these matters.

It should be noted that given the low cost to implement a restriction and the corresponding low bar required for proportionality, the Agency may propose a restriction should the concerns around enforceability and practicality be sufficiently resolved.

Lead in airgun ammunition (Use 3 and 6)

- **No restriction** is proposed at this time on the placing on the market or use of lead in airgun ammunition

A risk to the environment that is not adequately controlled has been identified for both live quarry shooting and target shooting with airgun ammunition. However, the Agency was not able to identify any workable restriction options to consider in the SEA.

Airgun ammunition would continue to be available on the market for indoor uses, which the Agency understands comprises approximately 80% of the total use in GB (British Shooting Sports Council (BSSC); Organisation #100) and it is not controlled

in the same way as bullets or shotgun cartridges. Airgun ammunition is available from a much wider range of suppliers (including online retailers). The outdoor uses of airguns often take place outside of formal ranges, for example on private land or back gardens.

The continued wide availability of airgun ammunition for indoor use (the large majority of total use) would highly likely undermine any practical enforcement of the placing on the market of airgun ammunition for outdoor use.

Alternatives to ammunition for airguns also provide unique challenges because of the regulations governing airgun ownership. It is possible that the use of one viable non-lead alternative in one airgun would work well, whereas its use in a different airgun would result in exceedance of the legislative muzzle energy threshold - which would then mean a Firearms Certificate would be required. Such effects could result in widespread, unintended criminal offences being committed.

For these reasons, including significant practical difficulties in the ability to monitor or enforce such a restriction, the Agency does not consider any restriction options to be monitorable or enforceable.

Transition periods

A transition period for the placing on the market and use of lead shot cartridges of 5 years is proposed. This is based on information provided by manufacturers on reasonable timescales required to scale up production to replace the amount of lead shot currently on the market. This transition period would apply to all uses of lead shot. Existing voluntary commitments by several UK shooting and rural organisations to use alternatives to lead shot by 2025 for live quarry shooting could still reduce the risks arising from this use during this period, although the Agency notes that these voluntary commitments were not supported by shot manufacturers, who indicated that 2025 would not be achievable for them.

The Agency is seeking further information on the appropriate length of this transition period during the public consultation, with a view to making this shorter, and therefore more rapidly addressing the relevant risks. For example, manufacturers may be able to achieve a quicker transition from lead for the smaller volume attributed to shot required for live quarry shooting. The Agency is also considering whether separate transition periods for placing on the market and use would be required, to allow a period of time for legally purchased ammunition to be used.

A transition period of 2 years is proposed for the prohibition on lead bullets for target shooting. Whilst it is expected that most shooting ranges already have risk management measures in place that would meet the proposed derogation criteria, sufficient time is needed for the development of the appropriate guidance, and then the subsequent installation of the risk management measures on other ranges.

Proposed restriction text

The text of the suggested entry in Annex 17 has been drafted to describe the recommendations of the Agency and is being proposed by the Agency for the consideration of the Appropriate Authorities. The final legal wording (i.e., to update

Annex 17 of UK REACH) would be decided by the Appropriate Authorities in due course if they were to decide to make legislation following the receipt of the opinion from the Agency.

Preface to the proposed restriction text

Whilst the three first clauses of the proposed text in Table 2 might at first suggest a complete prohibition on live quarry and target shooting with both lead shot and lead bullets **this is not the case**. There are a number of derogations within the text that would allow a number of uses, albeit often limited to specific areas or individuals. As such, the intended outcomes of the proposed restriction text are outlined below:

- The **use of lead shot for live quarry shooting** would be prohibited.
- The **use of lead shot for target shooting** would be prohibited. **However**, a derogation will allow for a small number of athletes, as identified by the appropriate sporting body (for example British Shooting), that are required to continue shooting lead shot for the purposes of international competition and training.
- The **sale or trade of lead shot** (for a price or otherwise) would be prohibited. **However**, a derogation will allow for those athletes referenced above to continue to source the lead shot required for international competition and training.
- The **sale or trade of lead bullets** (for a price or otherwise) would **not** be prohibited, since these would continue to be available for indoor shooting which is out of scope of this restriction.
- The **use of lead bullets for live quarry shooting** would **not** be prohibited.
- The **use of lead bullets for outdoor target shooting** would be prohibited. **However**, a derogation would allow for this use to continue at sites that have controls in place to reduce the identified risks to the environment, and documentation indicating why these controls are appropriate. **In practise**, these controls, which include de-leading of ranges, are broadly expected to be in place by the majority of existing outdoor shooting ranges.
 - o This means that the majority of outdoor shooting ranges could continue to operate and allow the use of lead bullets.
- The **use of lead ammunition in air weapons** would **not** be prohibited.
- The **sale or trade of lead ammunition for air weapons** (for a price or otherwise) would **not** be prohibited.

To note that some of these intended outcomes may change as a consequence of the information received during the public consultation on the draft socioeconomic opinion.

Table 2 Proposed text for the restriction

Designation of the substance	Conditions of the restriction
Lead and its compounds	1. Shall not be placed on the market in a concentration equal to or greater than 1% w/w in shot
	2. Shall not be used in a concentration equal to or greater than 1% w/w: <ul style="list-style-type: none"> a. in shot b. in any other projectiles not defined as shot (“other projectiles”)
	3. An outdoor ‘shooting range’ shall not allow the use of lead and its compounds in a concentration equal to or greater than 1% w/w in other projectiles.
	4. By way of derogation: <ul style="list-style-type: none"> a. Paragraph 1 shall not apply to the placing on the market of lead shot if the supplier has been allowed by the relevant enforcing authority to place on the market lead shot for target shooting b. Paragraph 2a shall not apply to the use of lead shot if the individual athlete as identified by the appropriate sporting body has been allowed by the relevant enforcing authority to use lead shot for target shooting c. Paragraph 2b shall not apply to the use of lead in other projectiles for live quarry shooting <i>[note: <u>subject to consultation</u>]</i> d. Paragraph 2b shall not apply to the use of lead in other projectiles if the weapon is an airgun e. Paragraph 2b shall not apply to the use of lead in other projectiles where the use only takes place at a ‘notified site’ f. Paragraph 3 shall not apply to the use of lead in other projectiles if the weapon is an airgun g. Paragraph 3 shall not apply to the use of lead in other projectiles where the outdoor shooting range: <ul style="list-style-type: none"> i. is a ‘notified site’, and ii. takes action to reduce the ‘identified risks to the environment arising from the

Designation of the substance	Conditions of the restriction
	<p>use of lead bullets for outdoor target shooting', so far as is reasonably practicable, and</p> <p>iii. maintains documentation regarding the action in 4(g)(ii), making this available to an enforcing authority upon request</p>
	<p>5. Entry into force of the restriction:</p> <p>a. paragraph 1 and 2a shall apply 5 years from entry into force of the restriction <i>[note: <u>subject to consultation</u>]</i></p> <p>b. paragraph 2b and 3 shall apply 2 years from entry into force of the restriction</p>
	<p>6. This restriction on lead in ammunition shall not apply to the following applications: indoor target shooting, police, security services, military, technical testing and/or proofing, testing and development of materials and products, forensic analysis, historical and other technical research or investigation.</p>
	<p>7. For the purposes of this restriction:</p> <p>a. 'shot' means pellets used [or intended for use in quantity] for shooting with a firearm;</p> <p>b. 'other projectiles' means any projectile not defined as shot</p> <p>c. 'live quarry shooting' means pursuing and killing live quarry using a firearm;</p> <p>d. 'projectile' means an object intended to be expelled from a firearm, irrespective of the means of propulsion;</p> <p>e. 'target shooting' means shooting at any inanimate (non-living) target with a firearm.</p> <p>f. 'airgun' means a firearm for which the projectile is propelled by compressed gas</p> <p>g. 'shooting range' means a site where target shooting occurs</p> <p>h. 'notified site' means a shooting range that has submitted a notification to the relevant enforcing authority. The enforcing authority shall make a list of</p>

Designation of the substance	Conditions of the restriction
	<p>notified sites publicly available. A notification shall include:</p> <ul style="list-style-type: none"> i. Name of the site ii. Address of the site iii. Name of the primary Range Safety Officer (RSO) or equivalent for the site iv. Contact details of the primary RSO or equivalent for the site v. Declaration that action has been taken to reduce the ‘identified risks to the environment arising from the use of lead bullets for outdoor target shooting’, so far as is reasonably practicable <p>i. ‘identified risks to the environment arising from the use of lead bullets for outdoor target shooting’ mean:</p> <ul style="list-style-type: none"> i. Risks to ruminants and grazing wildlife ii. Risks to soil iii. Risks to water

2.1 Alternatives to a REACH restriction

As there are both human health and environmental risks from lead exposure, any alternatives must be able to address both. Whilst several potential alternatives are discussed below, they either would not address the risks presented or would not be enforceable.

Voluntary Measures

In February 2020, several UK shooting and rural organisations produced a joint statement (BASC, 2020) committing to the use of alternatives to lead ammunition for the shooting of live quarry by 2025. A voluntary move away from lead to non-lead alternative shot would eliminate future risks to the environment and to human health via the consumption of game meat contaminated with lead ammunition. However, this will only be effective if all organisations and individuals engaged in the activity sign up to the voluntary measures and are committed to a change of behaviour. Also, the current voluntary measure is only applicable to the use of lead shot for live quarry shooting and does not extend to the use of lead shot for target shooting or to bullets and airgun ammunition. In addition, individuals that are not members of clubs

or organised groups would not necessarily be covered by this voluntary agreement. As such, further voluntary measures might be needed for this approach to achieve significant effectiveness.

Information in the supply chain

Consideration could also be given to the provision of information in the supply chain to:

- inform users about the negative consequences of using lead ammunition for both the environment and human health,
- promote the availability of alternatives and/or
- highlight the transitional periods of any restrictions or other measures in place (e.g., as outlined in this section).

This could be achieved through the provision of information at the point of sale or by the inclusion of labelling on the packaging of ammunition, for example. The Agency has not included this in the package of measures under the proposed restrictions as there might be more effective ways to communicate this information (e.g., via direct engagement with suppliers and shooting organisations). However, further consideration could be given to this provision as part of a wider suite of measures.

Existing regulations

Regulations prohibiting the use of lead shot for shooting over wetlands and certain bird species were introduced across England, Wales and Scotland between 1999 and 2004. There is the possibility of extending the existing legislation to cover other uses of lead shot; however, as these regulations do not currently cover target shooting or shooting with firearms other than shotguns, they would need significant modification. These regulations are also put in place on a devolved basis so would require individual arrangements to draft and lay statutory instruments. Additionally, there are already slight differences between these pieces of legislation which might need further investigation to ensure consistency in intent. Available evidence suggests that breaches of the regulations are high, and whilst extending them to full prohibition on use might help overall compliance, it would not prevent the placing on the market of lead ammunition.

Similarly, the Control of Lead at Work Regulations (CLAW) make robust provision aimed at monitoring and minimising exposure to people who handle lead compounds in the workplace. Given that the main risks from lead assessed in this opinion are the primary and secondary poisoning of birds, and that the human-health risks predominantly apply outside of the workplace via the ingestion of game meat that is contaminated with ammunition-derived lead, the application of CLAW would have very little impact. For the activity of producing lead-based ammunition in GB, for range operators, and for any other occupation involving exposure to lead, employers already have obligations to protect their workers under CLAW.

Meat preparation measures

Meat hygiene measures and stewardship programmes to minimise the amount of metal in meat for human consumption are already in place. However, meat can still contain small fragments and particles of metal that cannot be easily detected and that can be far from the shot site. Further development of labelling of food products that may contain lead, e.g., detailing the risks associated with lead consumption, could be considered. At best, these measures might reduce the risk of human exposure, but they would not eliminate it. In isolation, they also would not reduce release to the environment and would not address the environmental risk. They would be ineffective for meat that is not marketed; i.e., the proportion of meat that is consumed by hunters and their families/friends or that is distributed to workers at shoots.

Financial incentive

The introduction of a tax on the sale of lead ammunition could be used to influence the choices made by individual shooters. By increasing the price of lead ammunition relative to alternatives, the tax would create an incentive to switch to alternatives. However, taking shot as an example, steel shot is already cheaper than lead shot and can be used effectively in most shotguns in current use. Despite this, the uptake of steel shot has been slow and its use in GB is currently very limited. This indicates that such a tax might not be effective in reducing the amount of lead emitted to the environment; shooters are already willing to pay a premium to continue shooting with lead.

3. Procedure for adoption of the opinion

On 29 April 2021, HSE received a request from the Defra Secretary of State, with the agreement of the Scottish Government and the Welsh Government, to prepare an Annex 15 restriction dossier assessing the use of lead in ammunition.

Table 3 Procedure for the adoption of the opinion

Article under which the restriction dossier has been prepared:	Article 69(1)
Risks to be addressed:	<p>This restriction aims to address the risks posed to human health and the environment that arise from the use of lead ammunition.</p> <p>Military, police, and non-civilian uses are excluded from the scope of any potential restriction, as are indoor uses (such as at indoor firing ranges) and lead-containing propellants.</p>
Date the Registry of Restriction Intentions was updated in accordance with Article 69(5):	29 April 2021
Stakeholder mapping:	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Key information sources used:	<p>ECHA’s dossier proposing a restriction on ‘Lead in outdoor shooting and fishing’ (2022a)</p> <p>The opinion of ECHA’s Risk Assessment and Socioeconomic Assessment committees (RAC and SEAC) on the Annex XV dossier proposing restrictions on Lead in outdoor shooting and fishing (2022b)</p> <p>ECHA’s Committee for Risk Assessment Opinion: Scientific evaluation of occupational exposure limits for lead and its’ compounds. (2020)</p>

	<p>ECHA's Committee for Risk Assessment Opinion and Annex A: Proposing harmonised classification and labelling at EU level of Lead. (2018a)</p> <p>ECHA Background Document to the opinion on the Annex XV dossier proposing restrictions on lead compounds. (2018b)</p> <p>ECHA Annex to Annex XV restriction report - lead in gunshot in wetlands. (ECHA, 2017a, 2017b)</p> <p>ECHA Guidance on information requirements and Chemical Safety Assessment Chapter R.16: Environmental exposure assessment. (2016)</p> <p>ECHA Background document to the Opinion on the Annex XV dossier proposing restrictions on Lead and its compounds in articles intended for consumer use. (2014)</p> <p>ECHA Background document to the opinions on the Annex XV dossier proposing restrictions on Lead and its compounds in jewellery. (2011)</p> <p>ECHA Guidance on information requirements and chemical safety assessment Chapter R.10: Characterisation of dose [concentration]-response for environment. (2008)</p> <p>EFSA, Panel on Contaminants in the Food Chain (CONTAM) Scientific Opinion on Lead in Food. EFS2 8. (2010)</p> <p>The Lead Ammunition Group (LAG) update report (2018)</p> <p>LAG: Lead ammunition, wildlife, and human health: a report prepared for the</p>
--	---

	<p>Department for Environment, Food and Rural Affairs and the Food Standards Agency in the United Kingdom (2015a)</p> <p>Agency Literature search</p> <p>Call for Evidence (23 August 2021)</p>
Call for evidence:	<p><input checked="" type="checkbox"/> Yes</p> <p>Start date: 23 August 2021</p> <p>End Date: 22 October 2021</p> <p><input type="checkbox"/> No</p>
Information received during the call for evidence	<p>93 respondents provided information to the call for evidence. 7 confidential attachments and 59 non-confidential attachments were also provided by respondents.</p>
Stakeholder Consultation meetings held during the drafting stage:	<p><input checked="" type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p> <p>04 October 2021 (online) – Meeting with British Association for Shooting & Conservation (BASC) to provide update on the restrictions process and asked to submit any evidence to the Call for Evidence.</p>
Public consultation in accordance with Article 69(6):	<p>Start date: 6 May 2022</p> <p>End Date: 6 November 2022</p>
Information received during the public consultation:	<p>2,759 respondents provided information. 21 confidential attachments and 121 non-confidential attachments were also provided by respondents.</p>
Stakeholder Consultation meetings held and meetings with other interested parties/OGDs, also	<p><input checked="" type="checkbox"/> Yes</p> <p>02 September 2022 (online) - Discussions with representatives from the Danish</p>

attendance at external events during the first public consultation:

Nature Agency to discuss lessons learnt from the Danish experience of their long-standing lead-shot ban and the upcoming ban on lead bullets for hunting.

05 September 2022 (online) - Meeting with the Director of the GTA. Discussions at this meeting centred around bullet and shot manufacturing quantities, suitability of alternatives and challenges in any transition from lead to alternative material ammunitions.

06 September 2022 (online) - Meeting with BASC to discuss quantities and alternatives for ammunitions, risk management measures, potential for buy-back schemes or licensing schemes, and thoughts on enforcement of restriction for lead shot and/or lead bullets. Officials from the Environment Agency enforcement team were in attendance.

26 September 2022 (online) - Meeting with a group of conservation representatives from non-government organisations: British Deer Society (BDS), Wild Justice, The Royal Society for the Protection of Birds (RSPB), Wildfowl and Wetlands Trust (WWT) to discuss feedback on the Annex 15 dossier, compliance and enforcement of the wetlands' restriction, and additional evidence to be supplied to the public consultation.

28 September 2022 (online) - Meeting with representatives from shooting stakeholders: BASC, Historical Breechloading Small Arms Association, BSSC, Clay Pigeon Shooting Association (CPSA), Vintage Arms Association, Moorland Association, Welsh Airgun Field Target Association, National Gamekeepers' Association, Countryside Alliance, French Fédération Internationale de Tir aux Armes Sportives de Chass (FITASC) to discuss quantities and alternatives for ammunition, risk management measures, the potential for

	<p>licensing schemes for professional athletes, costs and practicalities of the proposed restriction and thoughts on enforcement of any restriction excluding lead shot, or partially restricting lead bullets. Officials from the Environment Agency's enforcement team were also in attendance.</p> <p>11 October 2022 (online) - Meeting with the CPSA to discuss their proposal for the derogation of 24g shotgun cartridges to link with the Olympic standard for competition, derogations for athletes in general including considerations for governing bodies to implement and control, lead alternatives, definitions of an athlete up to Olympic level and selection processes and pathways in place. Discussions were also had regarding CPSA-registered shooting grounds, local environments to shooting ranges, and the potential for recovery methods.</p> <p>11 October 2022 (online) - Meeting with the National Rifle Association (NRA) and the National Small-bore Rifle Association (NSRA) to discuss the operation of firing ranges, estimated quantities of ammunition used, suitability of alternatives, safety concerns of alternatives, derogations, and risk management measures.</p> <p>12 October 2022 (online) - Meeting with the BSSC to discuss suitability of alternatives, any transition period toward the use of steel, nuances in the uses of particular ammunitions, impact on industry and technology.</p> <p>03 November 2022 (online) – Meeting with the Office for Product Safety and Standards (OPSS) to discuss the Gun Barrel Proof Act and activities of Proof Houses in ensuring the safety of small arms.</p> <p>16 November 2022 (online) – Meeting with Dr. Mike Brock, associate professor</p>
--	---

	<p>in microeconomics at the University of East Anglia to discuss his research on lead in the environment.</p>
<p>Extension to statutory deadlines under Article 72(1):</p>	<p>The Agency, in line with the provisions in Article 72(1), informed the Appropriate Authorities that a 6-month extension of the deadlines for the risk assessment final opinion and the socio-economic analysis final opinion was required owing to the large number of responses to the public consultation. This extension was needed to sufficiently analyse these responses and take this information into account.</p> <p>Risk Assessment Final Opinion:</p> <p>Original deadline: 06 February 2023</p> <p>Extended deadline: 06 August 2023</p> <p>Socio-economic Analysis final opinion:</p> <p>Original deadline: 06 May 2023</p> <p>Extended deadline: 06 November 2023</p>
<p>Relevant scientific advice sought in accordance with Article 77(1A):</p>	<p><input checked="" type="checkbox"/> Yes</p> <p>Challenge Panel meetings held on:</p> <p>20 July 2022 (hybrid)</p> <p>24 November 2022 (hybrid)</p> <p>24 March 2023 (hybrid)</p> <p>07 July 2023 (hybrid)</p> <p>CP3 TBC</p> <p><input type="checkbox"/> No</p>

<p>Challenge Panel advice on Risk Assessment Opinion:</p>	<p><input checked="" type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p> <p>by Challenge Panel meeting on 07 July 2023</p> <p><input checked="" type="checkbox"/> Support (unanimous)</p> <p><input type="checkbox"/> Support with advisory</p> <p><input type="checkbox"/> Do not support</p> <p>NOTE: Comments provided by the Challenge Panel in writing before the meeting on 07 July 2023 and verbally during meeting have been considered in the opinion.</p>
<p>Challenge Panel advice on <u>draft</u> Socioeconomic Assessment Opinion:</p>	<p><input checked="" type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p> <p>by Challenge Panel meeting on:</p> <p><input checked="" type="checkbox"/> Support (unanimous)</p> <p><input type="checkbox"/> Support with advisory</p> <p><input type="checkbox"/> Do not support</p> <p>NOTE: Comments provided by the Challenge Panel in writing before the meeting on 07 July 2023 and verbally during the meeting have been taken into account in the draft socioeconomic opinion.</p>
<p>Date of formulation of the risk assessment opinion in accordance with Article 70:</p>	<p>06 August 2023</p>
<p>Public consultation in accordance with Article 71(1):</p>	<p>Start date: 10 October 2023</p> <p>End Date: 9 December 2023</p>
<p>Information received during the public consultation:</p>	<p>[] respondents provided information. TBC</p>

<p>Stakeholder Consultation meetings held and meetings with other interested parties/OGDs also attendance at external events during the second public consultation:</p>	<p><input type="checkbox"/> Yes TBC</p> <p><input type="checkbox"/> No TBC</p>
<p>Challenge Panel advice on final Socioeconomic Assessment Opinion:</p>	<p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p> <p><input type="checkbox"/> by Challenge Panel meeting on [date]:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Support (number) <input type="checkbox"/> Support with advisory (number) <input type="checkbox"/> Do not support (number) <p><input type="checkbox"/> by Challenge Panel written procedure on [date]</p> <ul style="list-style-type: none"> <input type="checkbox"/> No Recommendations <input type="checkbox"/> Minor Recommendations <input type="checkbox"/> Major Recommendations <input type="checkbox"/> Minority opinion (number)
<p>Date of formulation of the socioeconomic opinion in accordance with Article 71(2)</p>	<p>06 November 2023</p>

4. Opinion of the Agency

4.1 Risk Assessment

The following section outlines the risks which have been identified for lead in ammunition based on an assessment of hazard and exposure and a risk characterisation performed in accordance with Annex I, Section 6 of the REACH Regulation. The aim for this risk assessment is to determine if lead ammunition used in live quarry shooting or outdoor target shooting poses a risk to the environment and/or human health that is not adequately controlled, and to inform the development of risk management options to address those risks, including the scope and focus of risk management options.

4.1.1 Environment

Hazard

Lead is a non-essential, toxic element. The range of possible adverse effects of lead exposure have been investigated in experimental laboratory studies and evidence of the effects of lead on wildlife is available from pathology reports and observational studies. As well as causing mortality, lead exposure can result in sub-lethal effects on behaviour, development and reproduction. The use of lead ammunition has been linked to population-level effects in several raptor species from outside GB. In addition to the lethal and sub-lethal effects that can be measured, there will also be welfare impacts that are less easy to measure.

Lethal effects

Studies have shown that ingestion of a single lead shot pellet is enough in some circumstances to kill an individual bird (section 1.4.2.4 of Background Document). These studies used adult birds and it is expected that higher levels of mortality would have been observed if chicks or juveniles had been used (the dose being proportionally higher because of their lower body weight and higher levels of lead absorption during periods of active growth).

Sub-lethal effects

Sub-lethal and welfare effects will occur at exposure concentrations lower than those at which mortality occurs. A variety of sub-lethal effects have been reported, such as reduced body condition, altered immune responses, effects on blood parameters and the cardiovascular system, altered kidney histopathology and ocular lesions which may lead to blindness, and effects on reproduction, growth and development (such as reduced egg hatchability and juvenile survival). Welfare impacts can result in severe and prolonged discomfort, distress and pain. Impacts will depend on the amount of lead ingested in relation to the body size of the bird, with different species also having differing sensitivities. Sub-lethal and welfare effects have also been shown to increase the risk of predation, susceptibility to disease and death from other causes (e.g., collisions).

Thresholds

ECHA (2021) identified indicative thresholds that represent levels where adverse effects in birds are likely to occur based on previously published thresholds. However, it should be noted that sub-lethal effects have been found at lower lead concentrations than these. Regulatory restrictions placed on a range of anthropogenic uses of lead have resulted in a lowering of exposure levels in general and this has enabled effects to be determined at ever lower lead concentrations. In addition, technological advances have enabled the detection of lead concentrations in biological samples at lower levels and the ability to better study behaviour and other effects. The Agency notes that these factors could lead to a lowering of the thresholds. However, the available thresholds can still be used to provide an indicative interpretation of the effects of lead concentrations measured in birds. In addition, as more conservative novel data would only lower the thresholds, the current values can be used to estimate the minimum scale of potential effects.

The data for toxicological effects in ruminants are not generally from experimental testing of different exposure levels. Instead, they are accidental or unintentional exposures that have resulted in effects. However, they indicate that ingestion of lead ammunition can result in adverse effects, including death.

Soil

A generic predicted no-effect concentration (PNEC) for soil of 212 mg/kg dry soil (as lead) is presented in the EU REACH lead registrant's Chemical Safety Report (2020), based on ecotoxicity data for soil-dwelling organisms. The quality of the dataset, its appropriateness for different abiotic conditions (such as organic carbon content and pH) and derivation method have not been evaluated by the Agency for the purposes of this report.

Thresholds have been set for the acceptable concentrations of lead in forage and feed. Directive 2002/32/EC on undesirable substances in animal feed that has been retained in GB law sets a lead concentration of 30 mg/kg for forage (including hay, silage, fresh grass, etc.) with a moisture content of 12% and 10 mg/kg in other feed materials with a moisture content of 12 %.

Water

Under UK water quality legislation, lead and its compounds have an Annual Average Environmental Quality Standard (AA-EQS) of 1.2 µg/L (as a bioavailable concentration) in inland surface waters (defined as rivers and lakes and related artificial or heavily modified water bodies). A slightly higher AA-EQS of 1.3 µg/L can be used for other surface waters. The EQS expressed as a Maximum Allowable Concentration (MAC-EQS) is 14 µg/L (as a dissolved concentration). These standards apply in England and Wales under the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 and in Scotland under The Scotland River Basin District (Standards) Amendment Directions 2015.

Exposure

A fully quantitative exposure assessment for the various uses of lead in ammunition has not been attempted for the purposes of this report, due to the wide range of locations and environments where shooting can occur. Instead, the Agency has considered the evidence about the key exposure pathways for each use in GB. The use of source – pathway – receptor models is a standard approach in environmental risk assessment to determine whether there is potential for exposure, and therefore impacts, to occur. The available information on the releases of lead ammunition to the environment, evidence of lead exposure in birds and other animals that can be linked to use of lead in ammunition, and information on concentrations of lead in water, soil and vegetation that can be linked to the use of lead in ammunition is reviewed in the Background Document to determine exposure pathways relevant to GB.

Information on the tonnages of lead ammunition used in GB annually for each use was provided by a number of stakeholders during the public consultation. The Agency has assessed all the public consultation response comments and derived the total estimated volumes of lead released from lead ammunition to be approximately 7,100 tonnes per year.

Table 4 Annual tonnage per use

Use	Annual use (tonnes per year)
1. Live quarry shooting with shot	1,601
2. Live quarry shooting with bullets	3
3. Live quarry shooting with airgun ammunition	1
4. Outdoor target shooting with shot	5,359
5. Outdoor target shooting with bullets	112
6. Outdoor target shooting with airgun ammunition	12
Total	7,089

Notes: all figures rounded to the nearest tonne. Totals are calculated based on unrounded estimates and rounded to the nearest tonne, rather than summing individual rounded estimates.

Exposure routes

The principal routes of exposure to lead ammunition for birds and mammals are:

1. Primary ingestion (primary poisoning): the direct ingestion of lead projectiles or fragments of projectiles through normal feeding or foraging from the environment (for example, mistaking lead particles for grit, which is used to aid break-up of food or for minerals); and
2. Secondary ingestion (secondary poisoning): the indirect ingestion of lead through feeding on food contaminated with lead (for example, lead particles in prey/carrion, lead-contaminated tissues or plants).

The environmental receptor of main concern for both primary and secondary poisoning is birds.

Primary poisoning is of particular concern for bird species with muscular gizzards that ingest lead shot, mistaking it for grit. The lead particles are ground down in the gizzard, enhancing dissolution and then uptake within the intestine.

Secondary poisoning is particularly important for bird species that consume prey or carrion left in the environment that contain lead shot or lead bullet fragments within them.

Grazing animals can also be exposed directly through ingestion of lead ammunition or indirectly through increased lead concentrations in plant matter.

Primary exposure of birds

There is strong evidence from both GB and international studies that there is direct ingestion of lead shot by terrestrial and wetland birds (see section 1.4.5.1 of Background Document). There is one study reporting ingestion of airgun ammunition in birds, but the scale of this exposure pathway is considered by the Agency to be much lower than that of lead shot.

No evidence was found that birds directly ingest lead bullets or bullet fragments. Because of their size and shape, direct ingestion by birds is considered less likely than for shot or airgun pellets and so is not considered further in this assessment.

Secondary exposure of birds

There is also strong evidence from both GB and international studies (section 1.4.5.2.1 of Background Document) that secondary exposure of predatory/scavenging birds is a key exposure pathway for lead ammunition. This pathway is also thought likely to exist for scavenging mammals, although there are no GB data on this.

There are three ways by which indirect ingestion may occur.

Firstly, lead shot and airgun pellets can be directly ingested by birds. If these birds are preyed upon then the lead can move up the food chain.

Secondly, lead ammunition may be present in quarry animals that are shot but not killed. Quarry animals that are weakened, but not killed, are thought to be at greater risk of predation.

Thirdly, animals that are shot and killed but that are left unrecovered in the environment, or that are butchered in the field and have the viscera discarded, could also be eaten by predators/scavengers. Studies (section 1.4.5.2 of Background Document) have shown that lead shot and bullets fragment upon hitting the target, resulting in small pieces of lead being dispersed in the carcass.

The secondary exposure pathway is relevant to live quarry shooting with all forms of lead ammunition, and to all uses that result in primary ingestion, as this can then pass up the food chain.

Primary and secondary exposure of grazing and companion animals

There is evidence from the UK and other countries that mammals can ingest lead shot whilst grazing. This is considered a relevant exposure pathway for livestock (and likely wild animals) that feed in areas with high lead shot use (e.g., outdoor shooting ranges or rural areas with regular shoots). Similarly to birds, no evidence was found that animals directly ingest lead bullets or bullet fragments.

There is also evidence from the UK and other countries of an exposure pathway via silage harvested from areas contaminated with lead shot.

Companion animals may be fed meat contaminated with lead from ammunition, particularly dogs belonging to hunters that may be fed off-cuts of hunted game or surplus game. This is considered a relevant exposure pathway for this assessment. In addition, a recent study on lead concentrations in raw pet food identified shot and shot fragments and lead concentrations above the EU Maximum Residue Level (MRL), although this specific risk has been brought to the attention of the regulator for pet food and so is not considered further here.

Exposure to soil and water

GB data and evidence from other parts of the world show that soil lead concentrations in areas of intensive or repeated lead ammunition deposition will be above background levels. In GB, measured concentrations up to three orders of magnitude higher than natural background have been reported, whilst concentrations up to four orders of magnitude higher than natural background have been observed in other parts of the world. The lead in soil has the potential to be ingested and accumulated by soil organisms or to be taken up and accumulated by plants, both of which may then be eaten resulting in lead moving along the food chain. This exposure pathway is therefore relevant for those uses which result in high inputs of ammunition to the same sites (e.g., outdoor shooting ranges or rural areas with regular shoots). Target shooting ranges would be expected to have increased soil lead concentrations in a relatively limited area, closest to the target (i.e., within the berm or in front of the berm). Emissions of lead shot from target shooting or from shooting of live quarry regularly over the same site would be expected to result in increased soil lead concentrations over a wider area.

Lead compounds and lead powder can be relatively mobile in soil solution or runoff water, depending on the site-specific conditions. Therefore, where sites are contaminated by lead ammunition and are in close proximity to surface or ground water, there is a risk for the transport of lead into the aquatic environment. There have been no GB studies investigating the concentration of lead in surface waters or groundwaters from sites where lead ammunition is used. However, monitoring data from elsewhere and knowledge of the fate of lead from laboratory studies demonstrates that there is the potential for contamination of surface waters and groundwaters in areas of intensive ammunition use (e.g., outdoor shooting ranges or rural areas with regular shoots). The scale of this exposure pathway will depend on the amounts of lead emitted to the environment, site conditions, proximity of surface water courses or groundwaters and time. Increased water lead concentrations may occur both during and after the service life of the site, unless a remediation plan is

implemented. Aquatic organisms in surface waters may be exposed to the lead and may bioaccumulate lead, resulting in lead moving along the food chain. Wildlife and humans may be exposed via drinking water. This exposure pathway is therefore relevant for those uses which result in high inputs of lead in ammunition to the same sites (e.g., outdoor shooting ranges or rural areas with regular shoots).

Risk characterisation

A fully quantitative risk assessment for the various uses of lead in ammunition has not been attempted for the purposes of this report. Instead, the Agency has considered the available data on hazard, exposure pathways and reported impacts on individuals and populations to produce a description of the risk. As the source of the lead does not alter the impact, the various uses are considered together in a single environmental risk assessment for each receptor, noting the uses that are relevant for each identified risk as different risk mitigation measures may be available for each. Where possible, the Agency has considered whether the relative scale of the risk between different uses can be determined for each receptor.

The risk assessment considered adverse effects on individual animals and populations qualitatively or semi-quantitatively. Thresholds representing a concentration below which adverse effects are not expected to occur have been used to assess the risk to soil-dwelling organisms and grazing animals. A risk that is not adequately controlled is considered to have been demonstrated for the purposes of this restriction proposal when exposure concentrations are greater than those at which adverse effects are expected.

Risks via primary exposure to birds from lead shot and bullets

To determine the risk of primary ingestion of lead shot to birds, published estimates of mortality rates for UK populations or UK-relevant species of several game birds were used. Three studies report modelled mortality rates. Pain *et al.* (2019) used the data on ingestion rates of lead shot in Common Pheasant and Red-legged Partridge to estimate mortality rates caused by lead ingestion of 0.56 and 0.32 %, respectively, for the UK populations. A study by Meyer *et al.* (2016) modelled the percentage mortality for Grey Partridge to be 4% for deaths directly related to lead shot ingestion in continental Europe based on results from pathology reports. Meyer *et al.* (2022) estimated a combined mortality rate for species of gallinaceous birds that may ingest lead shot when foraging for grit or seeds. The UK species included were Red-legged Partridge, Grey Partridge, Common Pheasant, Red/Willow Grouse. Mortality rates were based on published pathology reports diagnosing lead poisoning as the cause of death or indicative of sub-lethal effects. For the UK, the reported mortality was 0.99 % for mortality directly caused by lead ingestion and 2.06 % for mortality indirectly caused by lead ingestion, as sub-lethal effects increased the chance of death from other causes.

Based on the data on mortality rates of terrestrial birds, and for the purposes of this assessment, **the Agency has selected a range of values between 0.1 and 5%** to represent those terrestrial birds potentially exposed and at direct risk of death from the primary ingestion of lead shot. A range has been selected as there is uncertainty

in this number and the number of studies on which this is based is limited and does not cover all species potentially at risk. This range is considered by the Agency to be a reasonable estimate based on the data available.

The UK terrestrial bird species at most risk of primary ingestion of lead shot were identified based on:

- evidence of ingestion of lead shot by these species
- extrapolation from species in the same taxonomic group based on similarity of feeding ecology
- and an assessment by the United Nations Environment Programme Convention on Migratory Species (UNEP/CMS) *ad hoc* Expert Group.

UK population estimates for these bird species combined with the mortality rates results in **an estimate of 16,100 to 804,000 terrestrial wild birds in the breeding population at risk of death annually from primary ingestion of lead shot** in the UK. This estimate reflects a minimum number of birds at risk of death and the risk assessment must consider the wider sub-lethal as well as lethal effects, of which many more birds will be affected.

In addition, wetland birds that feed on terrestrial areas are considered to be at risk. Published estimates adjusted by the Agency to account for reduced lead shot use over wetlands indicate 37,500 to 75,000 waterbird deaths annually.

While not wild bird populations, an additional 47,100 to 3,500,000 game birds bred and released for the purposes of hunting are also at risk of death annually from primary ingestion of lead shot. This broad range is based on 47.1 to 70 million pheasant and partridge released per year and using the same 0.1 to 5 % range as above (section 1.4.6.1.1 of Background Document). These estimates are a minimum number of birds at risk of death and the risk assessment must consider the wider sub-lethal as well as lethal effects, of which many more birds will be affected.

Risks via primary exposure to birds - airgun ammunition

Although an exposure pathway has been identified for the primary ingestion of airgun ammunition by birds, the risk from this exposure pathway for both live quarry shooting and target shooting is considered to be much lower than that of lead shot for the following reasons:

- The tonnage of airgun ammunition used in GB is much lower than that of lead shot (13 tonnes compared with 6,990 tonnes annually)
- Airgun pellets are larger than lead shot (typically 4.5 - 5.5 mm diameter compared with 2 – 4 mm diameter), meaning that a smaller proportion of bird species will mistake them for grit in the preferred size range and be able to ingest pieces of this size
- When used for target shooting against a solid target, lead airgun ammunition will deform into flatter shapes that may be less easily mistaken for grit and ingested

- Because a single projectile is fired each time from an airgun compared with a large number of shot from each firing, the number of airgun projectiles available in a close area will be much lower than the number of lead shot, reducing the likelihood of ingestion of multiple pieces of lead
- When used for live quarry shooting or target shooting, the aim is for each airgun pellet to hit the target and there is the potential for some to be removed from the environment, either by the collection of killed quarry or use of risk management measures for target shooting (e.g. collection traps on ranges, hand collection for home users).

Overall, although this exposure pathway cannot be ruled out, and so a theoretical risk has been identified, the scale of the risk is considered to be low for GB.

Risks via secondary exposure to birds from lead shot

Several UK studies have reported on the concentrations of lead in the liver, bones or blood of wild scavenging or predatory birds that were found dead or dying and collected for analysis. These concentrations can be compared with thresholds to provide an indication of the biological significance of the concentrations measured. Based on GB data for liver, blood and bone concentrations, there is evidence to suggest that deaths of wild Common Buzzards, Peregrine Falcons and Red Kites are being caused by lead poisoning. A larger proportion of the bird samples and a larger range of species were found to have levels of lead above background concentrations, in the range at which sub-clinical effects may be expected. Some studies have linked the sources of the lead in liver and bone to lead from ammunition by the use of lead isotope analysis (*Pain et al., 2007; Taggart et al., 2020; Walker et al., 2012*). Birds have also been found with lead shot in their oral cavity (*Molenaar et al., 2017*) and lead shot has been found in regurgitated food pellets (*Pain et al., 2007*). Although other species have not been found to have such high lead concentrations in the carcasses submitted for study, the samples are unlikely to be fully representative for each species and so should not be taken to mean that higher lead concentrations are never present. Samples are biased to those dead birds found and then submitted for analysis, so the geographical location of the samples may not match with those areas of highest exposure, and are often small in number.

Published studies have modelled the number of bird deaths that may result from secondary exposure to lead ammunition to be in the thousands in the UK, but greater numbers of birds would be expected to experience sub-lethal and welfare effects. The potential exposure pathway is clear and even if only a small proportion of the population ingests lead via secondary poisoning, large numbers of individual birds may be adversely affected.

Adverse effects on population-relevant endpoints have been observed in laboratory studies with birds at concentrations below those at which mortality is seen. A reduction in individual survival rates and adverse effects on population-relevant endpoints will affect the overall population size of a species, unless they are perfectly compensated for by complete density-dependent enhancement of other demographic variables. The point at which population-level effects may occur will

vary from species to species, and between locations and time, depending on what other stressors or compensatory factors are in place. The Agency considers that the population size of at least some bird species will be lower than that which would be expected in the absence of lead exposure from ammunition, but that the magnitude of the reduction in population size is uncertain.

The life history of the bird species is important in determining what the effects on population levels may be. Differences in feeding ecology, life span, age at first breeding and annual survival rate (from all causes of death) will all influence the scale of any adverse effects on population. Although the number of individual birds killed or the reduction in stable population size is of relevance, another consideration is whether the population can be sustained. Population-level effects are most likely to occur in species such as raptors that have lower natural annual mortality rates and lower annual reproductive rates, and bird species with lower initial population sizes are more at risk of extinction. Several of the bird species at highest risk of primary and secondary poisoning are identified as being of concern because of declines in numbers or ranges or are identified as being at risk of extinction (Stanbury *et al.*, 2021). The reasons for the status of the threatened species are varied, and this assessment does not attempt to link exposure to lead from ammunition as a specific cause for any of them. However, some populations of bird species that have feeding ecologies that increase the likelihood that they will be exposed to lead from ammunition, either via primary or secondary exposure, are already threatened.

The risk from lead shot for secondary poisoning results from its use for both live quarry shooting and target shooting, with exposure via lead shot embedded in prey or carrion or ingested shot in the alimentary tract of prey. When using lead shot for target shooting all of the lead shot is emitted to the environment. When used for live quarry shooting, the majority of shot will not hit the live target and will be emitted to the environment. Some of the emitted lead shot will be ingested by birds, but most will not enter the food chain. Many of the quarry killed using lead shot will be retrieved, so any embedded lead would not be relevant to secondary poisoning of birds. However, some will not be and quarry that are wounded but not killed may be more likely to be preyed upon and the lead shot embedded in them subsequently ingested. Overall, only a small proportion of the lead shot used annually is considered relevant for secondary poisoning.

Risks via secondary exposure to birds from lead bullets

The risk from lead bullets for secondary poisoning results from use in live quarry shooting, with scavengers eating the discarded quarry or gut piles that are contaminated with bullets or bullet fragments. For live quarry shooting the aim is for each bullet to hit its target, where the bullet expands and fragments but generally remains within the carcass. Many of the animals killed using lead bullets will be retrieved, so any embedded lead would not be relevant to secondary poisoning of birds. However, some of the carcasses will not be retrieved, and the viscera of those which are retrieved will generally be removed and discarded, and this is likely to contain lead bullet fragment.

Therefore, the Agency considers that for an equal tonnage of lead used as lead shot compared with lead bullets, a considerably higher proportion of the bullet tonnage is relevant for secondary poisoning than the proportion of shot tonnage.

Differences in the feeding ecology of raptor species in GB will also affect the likelihood of exposure to different types of lead ammunition. For bird species which feed on smaller game animals, exposure will primarily be through ingestion of lead shot in prey or carrion. In other species, for example Golden Eagle and White-tailed Eagle, which scavenge primarily on carrion and discarded viscera from larger game (particularly deer), exposure to large calibre bullets and bullet fragments will occur. Impacts at a population level are expected to be greater in those species that are longer lived and later to mature and with lower population sizes. These are generally the larger raptor species like Eagles. Therefore, although the tonnage of lead bullets used for live quarry shooting is much lower than the tonnage of lead shot emitted from live quarry shooting and target shooting, the impact on population sizes of the larger raptor species that are exposed to bullet or bullet fragments has the potential to be greater than the impacts on population sizes of smaller raptor species that are exposed to lead shot.

Risks via secondary exposure from airgun ammunition

As discussed for primary ingestion, the identified risks for airgun ammunition are the same as for lead shot, but the scale of the risk is anticipated to be much lower. For lead airgun ammunition, the scale of primary ingestion in GB is considered low. Therefore, the main pathway for secondary poisoning would be via its use for live quarry shooting. The aim is for each airgun projectile to hit the quarry with a single shot to the head or heart resulting in death. As the quarry are typically pests, these might not be retrieved from the environment, and the lead airgun ammunition could potentially be eaten by scavengers. However, the larger size of the airgun ammunition means that the likelihood of ingestion by scavengers will be lower than that for lead shot and each carcass would be expected to contain only a single projectile.

Conclusion on risks to birds

The Agency therefore considers that the use of lead shot (Uses #1 and #4), lead airgun ammunition (Uses #3 and #6) and the use of lead ammunition for live quarry shooting (Uses #1, #2 and #3) have been demonstrated to pose a risk to birds that is not adequately controlled.

Risks to mammals and companion animals

There is evidence from the UK and other countries that mammals can ingest lead shot whilst grazing and lead poisoning and mortality have been reported for cattle exposed via this route. This is considered a relevant risk for livestock (and wild animals) that feed in areas with high lead-shot use. Cases of lead poisoning have also been reported after ingestion of silage contaminated with lead shot in the UK and elsewhere. Concentrations of lead in vegetation grown in areas of high lead ammunition use are reported to exceed thresholds set for lead in forage and feed,

indicating that there may also be a risk of secondary poisoning of livestock via this route.

The Agency therefore considers that the use of agricultural land for live quarry shooting with lead shot (Use #1) and the use of target shooting with lead ammunition (Uses #4, #5 and #6) have been demonstrated to pose a risk to the environment that is not adequately controlled.

Exposure of mammalian scavengers to lead ammunition through contaminated prey and gut piles, discarded meat or unrecovered game has been identified as a relevant exposure pathway for uses which involve the shooting of live quarry in GB. The Agency considers that mammalian scavengers will be exposed to lead from ammunition and that, depending on the level of exposure, this will result in adverse effects, but the scale of the risk as a result of this pathway is unknown. In addition, exposure of companion animals fed lead ammunition-contaminated meat off-cuts or surplus game that contains wild-shot game has been identified. Although there is evidence that this exposure pathway exists, and published modelling studies indicate that both chronic and acute (including death) toxicity may be expected, the scale of the risk is unknown in GB. The Agency therefore considers that the use of lead ammunition for live quarry shooting (Uses #1, #2 and #3) can pose a risk to scavenging mammalian wildlife and companion animals that is not adequately controlled.

Risks to soil and water

Repeated shooting with all forms of lead ammunition at a site, without any risk management measures in place to capture or collect and remove the lead ammunition, will result in increasing soil lead concentrations over time. A small number of GB studies have measured the concentrations of lead in soil samples collected from shooting ranges that had been in use for between 10 and 40 years. All three studies from GB clay pigeon sites report soil concentrations that are significantly greater than the PNEC for soil. The single study from a game shooting ground did not exceed the PNEC, although how representative this study is of other sites is unknown. The Agency notes that even at a single shooting range, soil lead concentrations would be expected to be highly variable depending on the proximity to the target and the site conditions. Variability between sites would also be expected dependent on to the length of service life, intensity of shooting at the site and type of shooting. The limited number of GB soil monitoring studies clearly demonstrate that soil lead concentrations can be elevated considerably above background at shooting ranges and achieve concentrations that are a trigger for risk management action. A single study from a game shooting ground does not allow this risk to be ruled out for that use.

The Agency considers that the concentration of lead in soil at sites used for intensive or regular shooting for extended periods of time can reach levels that result in risks to the environment that are not adequately controlled (Uses #1, #4, #5, #6).

There have been no GB studies investigating the concentration of lead in surface waters or groundwaters from sites where lead ammunition is used. Therefore, there

are no GB monitoring data for lead in the aquatic environment as a result of lead ammunition use that can be compared to the EQS to determine if a risk would be identified. Studies investigating the movement of lead through the soil at shooting ranges outside GB have reported limited movement of lead down through soil layers due to its fate properties. However, the potential for lead contamination of groundwater will depend on a combination of the type and amount of lead ammunition emitted to the environment, soil chemistry and groundwater vulnerability that is site-specific. Increased lead concentrations have been reported in surface run-off, especially during times of increased water movement, either due to precipitation or snow melt. Increased lead concentrations in surface waters as a result of lead ammunition use have been linked to observations of adverse effects in fish.

The Agency considers that the concentration of lead in surface and ground water at sites used for intensive or regular shooting for extended periods of time will result in concentrations increasing above background levels (Uses #1, #4, #5, #6). The scale and any associated risk will depend on the site-specific details (e.g., the amounts of lead emitted to the environment, site conditions, proximity of surface water courses or groundwaters and time since deposition).

4.1.2 Human health

Hazards

The main routes of absorption of lead are via inhalation (up to 100%) and ingestion (15-45% in adults, approximately 50% in children), with dermal absorption reported to be low (< 0.06%). Absorbed inorganic lead is distributed to soft tissues and organs (e.g., liver, kidneys) and mineralising systems (bones, teeth), where it accumulates. In adults, approximately 90% of the lead body burden is in bone, whilst in children this value is approximately 70%. Half-lives are reported to be about 40 days in blood and soft tissue and several decades in bone. During periods of bone resorption or increased calcium demand (i.e., pregnancy, lactation, menopause and osteoporosis), lead can be released from the bones into the bloodstream and result in an increase in blood lead levels (BLLs). Lead can also be passed from mother to infant *in utero* (placenta to foetus) and via breast milk, although maternal milk is estimated to be a minor source of exposure for infants (PHE, 2017). Bradbury and Deane (1993) reported that the blood-brain barrier is permeable to lead ions.

Inorganic lead is not metabolised or bio-transformed in the body, but forms complexes with various proteins and non-protein ligands. Lead is primarily excreted in the urine (> 75%), whilst approximately 15-20% is excreted via bile and faeces. BLLs are an indicator of recent exposure (approximately the past 30 days), whilst lead in bone is regarded as a biomarker of long-term exposure.

There are limited data on the acute toxicity of lead in humans, but reported effects include abdominal pain, constipation, nausea, vomiting and kidney effects. Inorganic lead is not irritant to the skin or eyes and is not a skin sensitiser.

Chronic exposure to lead is associated with a wide range of health effects. These effects include toxicity to the blood system, nervous system, kidneys, cardiovascular system, liver and the immune system. The most sensitive organs and tissues (i.e., those that are affected at the lowest doses of lead) are the cardiovascular system (especially elevation of systolic blood pressure), the kidneys and the nervous system.

Variable results have been obtained from *in vitro* and *in vivo* genotoxicity studies (PHE, 2017). The International Agency for Research on Cancer (IARC) identified lead as a Group 2A carcinogen (probably carcinogenic to humans), although EFSA concluded that human exposure to lead through food was unlikely to represent a significant cancer risk, since tumours were only induced in rodents at doses that exceeded human dietary intake (EFSA, 2010).

Lead is known to cause reproductive toxicity in humans. There is strong evidence from humans and experimental animals that repeated exposure can adversely affect male fertility. Repeated exposure to lead during pregnancy is associated with spontaneous abortion, premature birth, foetal growth restriction and maternal hypertension. Adverse effects on the developing nervous system (developmental neurotoxicity) in foetuses and young children are of particular concern; even at low levels of lead exposure, cognitive development and intelligence quotient (IQ) are reduced.

Key effects of lead relevant to this assessment

The key human-health effects that were considered in the Background Document were

- **in the developing foetus and young children** (seven years of age and younger): developmental neurotoxicity
- **in adults:** cardiovascular effects (elevation of systolic blood pressure)
kidney toxicity.

Authoritative reviews of these effects have concluded that none of them has a threshold below which they do not occur.

EFSA (2010) identified these as the key effects for its risk assessment of lead contamination in food and calculated benchmark-dose lower confidence limits (BMDLs) for the associated health outcomes. The lowest BMDL (0.5 µg Pb/kg bw/day) was for developmental neurotoxicity and corresponded to a 1% change in full-scale IQ (a decrease in IQ by one point). Whilst a one-point decrement in IQ is a subtle effect that cannot be reliably measured or attributed on an individual basis, the UK Committee on Toxicity (COT, 2016) regarded the consequence of a downward shift in the distribution of IQs in the population to be 'an increase in the number of individuals with learning difficulties and a decrease in those with an exceptionally high level of intellectual ability.'

The BMDLs that EFSA calculated for kidney effects and cardiovascular effects in adults represented a 10% increase of chronic kidney disease and a 1% increase in systolic blood pressure, respectively; at these response levels, both these effects have been concluded to impact human health at the population level (EFSA, 2010; JECFA, 2011).

The other potential health effects of lead occur at higher doses and were not further assessed.

Exposure

Exposure of humans to **ammunition-derived lead in game meat** was assessed in the Background Document. The highest consumers of game meat are hunters and their families. Employees of shoots are also likely to be high consumers.

Existing food regulations (European Commission Regulation (EC) No. 1881/2006 [as retained in GB law] “setting the maximum level of certain contaminants on foodstuffs”) prohibit the sale of specific food commodities that contain lead above maximum specified levels (*100 and 500 µg/kg wet weight respectively in the case of lead for meat (muscle) and offal of cows, sheep, pigs and poultry respectively*). However, these regulations do not extend to game meat.

Direct exposure to humans from the manufacture, handling and use of lead ammunition and additional indirect exposures from contamination of drinking water and other food types were not in scope of the assessment. Nevertheless, the proposed restriction would reduce both occupational exposures of those currently concerned in lead-ammunition manufacture and handling in the supply chain and secondary exposures via the environment.

Lead in game meat

Lead ammunition that hits an animal often fragments into small particles upon impact. The degree to which this occurs, and the consequent lead contamination of the meat, depends upon the type of ammunition and its velocity.

Lead shot

As reported in the Background Document and the associated Annex B.9.2, many publications report contamination of game meat with shot-derived lead particles. In recognition of the potential for contamination of game meat with ammunition-derived metal, meat hygiene measures and stewardship schemes are in place in the UK to minimise the amount of metal in meat sold for human consumption. Additionally, game handling to remove obvious ammunition fragments by hunters and their families / friends is reported to be reasonably widespread.

However, the FSA has stated that, in relation to small game, it is impracticable to remove all small lead pellets, since this would be overly time-consuming and would likely render the birds unsellable. Furthermore, the use of lead shot to shoot game

birds can result in fragments derived from the pellets that are too small to be detected by the human eye and that can be scattered throughout the bird. Some investigations into ammunition-derived lead contamination of UK meat samples from wild game birds have measured lead concentrations that exceeded the EU maximum level (EURL) for non-game meat. A widely-cited study and one that has been used to estimate the human-health impacts of lead in game meat in the UK is that by Pain *et al.* (2010); in this analysis of lead concentrations in the meat of six species of game birds, differences between them were recorded (from 341 µg/kg in a whole meal per unit of meat with mallard to 8054 µg/kg with partridge; arithmetic mean 1181 µg/kg), although these were not statistically significant. In one small survey (publicly available but not peer reviewed) of game-bird meat samples from UK and Irish outlets of a supermarket, high lead levels remained in some of the samples even after the whole shot pellets had been removed (Wild Justice, 2023).

Lead bullets

Likewise, the use of lead bullets can result in meat contamination. The concentration of lead and extent of particle distribution detected in meat from animals shot with lead bullets depends upon the type of bullet used. Lead bullets that are designed to expand upon impact are more likely to result in larger numbers of (microscopic) particles/fragments that are dispersed further from the wound channel, and hence are more difficult to detect and remove. Reported maximum distances of fragments from wound channels have ranged from 5 cm for the more stable types of lead-containing bullets (those that deform without fragmenting) to 45 cm for those that are designed to rapidly expand and fragment. There also tend to be more, smaller fragments when the projectiles hit bone. Therefore, smaller bullet fragments and lead particles have been detected in meat that is intended for human consumption, i.e., relatively far from the wound channel. Average lead concentrations above the EURL have been reported in UK wild deer shot with lead ammunition, presumably bullets.

Overall, lead concentrations in some meat samples (game birds, deer) have exceeded the EURL for non-game meats. The impacts of ammunition on lead concentrations in game meat tend to be unevenly distributed, especially in larger game: there can be large variations in lead concentrations in different cuts of game meat from the same animal, depending on the distance from the bullet wound channel. As noted above, however, bullet-derived small lead particles and increased lead concentrations can occur in meat that is consumed by humans. Nevertheless, the LAG concluded that mean lead concentrations are likely to be generally higher in game meals made from small game (game birds and waterfowl) shot with lead gunshot than meals made from large game (e.g., deer) shot with lead bullets.

Low-velocity ammunition

Ammunition types for use at lower velocities than shot and bullets (e.g., airgun ammunition) are unlikely to represent a risk to human health, since they generally do not fragment upon impact.

Game meat consumption in the UK

Some information on game meat consumption, primarily game birds, in the UK is available. Estimates of annual game-bird consumption in the UK have been made from National Diet and Nutrition Survey data (NDNS), although limitations of this data include the small sample size, the 4-day average from a diet diary being somewhat unreliable for infrequently consumed food items, and the lack of information on whether the birds were wild-shot or farmed. Nevertheless, this data indicated that at the time of the survey, 11,232 tonnes of game-bird meat was consumed per year (95% C.I. 9,162 – 16,251). PACEC (2006) estimated the annual UK consumption of game bird meat to be 4,940 – 9,880 tonnes. The Agency was not able to identify information on quantities of other types of game hunted with shot that is consumed in GB amongst either hunters and their families or the general population. Likewise, there was no information on the consumption of game species hunted with shot versus other ammunition, e.g., lead bullets. The NDNS (FSA, 2002) indicated a mean daily per capita consumption of all meat from species shot as game animals in the UK of 0.7 g per day (approximately 250 g/year), which included meat from farmed animals as well as wild-shot game. Green and Pain (2015a) considered that the average per capita consumption of wild-shot game in the UK is low and ‘probably less than 1% of average per capita consumption of all meats.’

Whilst the consumption of game meat amongst the general population appears to be low, those involved in game shooting and their family members and friends are likely to eat far more game meat. The Food Safety Agency in Scotland (FSAS) defined high-level consumers as those eating wild game at least once per week during the shooting season and noted that such meat was generally eaten no more than once or twice a week. BASC and Countryside Alliance estimated in 2014 that 9,000 (midpoint of the range 5,500 – 12,500) children under the age of 8 and about 44,500 adults (range 27,000 – 62,000) from the UK shooting community consumed at least one game meal per week (all types of game, one portion assumed to be ≥ 100 g), averaged over the year.

The average game meat consumption of high-level consumers in the UK, as estimated by NDNS data, was cited to be 47.4 g daily (equivalent to 331.5 g weekly or 17.2 kg per year) (FSAS, 2012). Taylor *et al.* (2014) also used the NDNS data to conclude that consumption of game birds by women of child-bearing age and children ≤ 6 years old was relatively low (0.9% of the latter age group, compared with 2.7% of the total UK NDNS sample). FSAS (2012) considered that the rates of game meat consumption might be rather lower for young children than for adults; amongst those surveyed, who comprised butchers, game dealers, shooters and game-keepers, 23% of children under 5 did not eat game meat. The Diet and Nutrition Survey of Infants and Young Children (DNSIYC) (Department of Health and Food Standards Agency, 2011) included game meat in the ‘other meat and meat products’ category, although the proportion of those sampled that consumed this meat type wasn’t separately reported. Since there was no specific information on the quantity of

game meat consumed by toddlers, FSAS (2012) applied portion sizes of 40 g (large game) and 30 g (small game) for toddlers, estimated from NDNS data on toddlers' consumption of meat and poultry compared with adults. The different estimates of numbers of high-level UK consumers indicates that they comprise in the region of 0.084 – 2.52% of the population (adults and children combined).

Relative partitioning between lead exposure from shot and bullets

Although the quantity of lead shot used for LQS is far greater than that of lead bullets used for LQS, the different shot-to-kill ratio of each ammunition type could mean that humans are exposed to more lead via secondary exposure per tonne of lead bullets than per tonne of lead shot.

For shot, the shot:kill ratio is estimated to be between 4:1 to 5:1 (section 1.4.3 of the Background Document). An annual quantity of 1,601 tonnes of gunshot to shoot wild quarry has been estimated to result in about 4 tonnes of lead entering and being retained by quarry animals (see section 1.5.2 of the Background Document). The Agency notes that this assumes that all lead shot for LQS is used to shoot pheasant, which, in a survey of six UK game bird species, had the highest mean shot per bird (3.36/bird). In comparison, the overall mean for the six species was 2.17 shot/bird, and the lowest mean value was 0.95 shot/bird for woodpigeons (Pain *et al.*, 2010).

Pain *et al.* (2010) estimated that 0.308% of shot would need to be present as small fragments to result in the lead concentrations found in the meat of game birds from which whole shot had been removed prior to analysis. Of a 3.6 tonne estimate of shot remaining in prey available for human consumption (if 10% of birds hit are unretrieved or escape injured, and assuming that the remainder would be destined for human consumption), this would represent a potential annual exposure to humans of approximately 11 kg of lead fragments in food, once shot have been removed at the table or during food preparation.

In contrast to the shot:kill ratio for shot, 95.5% of first shots at deer have been reported to hit the target. On average 17% of the weight of copper-jacketed lead-core bullets was present in the carcass as fragments (Knott *et al.*, 2010). Most of the risk to human health from lead bullets is expected to arise from large-calibre bullets. If 1 tonne of lead in large-calibre bullets (Table 1.17, section 1.4.4 of the Background Document) were used annually to shoot deer, it might be predicted that 0.96 tonnes would hit a deer target (the main target species) and that about 0.163 tonnes (163 kg) would be present in the quarry as lead fragments. Knott *et al.* (2010) reported that 86% of bullet fragments (which would equate to 140 kg) were found in the non-viscera part of the carcass and so might be consumed by humans, although it was acknowledged that some of these fragments would be too large to be consumed by people. Furthermore, the proportion of the species shot with bullets that enter the human food chain might be small.

The estimated quantities of lead in different meat types are, in some cases, calculated from relatively small surveys and rely upon several assumptions. The Agency was not able to identify information on the tonnage of large game that is consumed annually in the UK, nor on the number of high-level large-game consumers or proportion of small-game versus large-game consumption amongst this population.

Pain and Green (2022) reported relatively little variation in lead concentrations in different European small game species (game birds, hare, rabbits) when sample sizes are very large; they reported the arithmetic mean to be 5.205 mg/kg. Some reported mean lead concentrations in deer meat range from 0.195 mg/kg (FSAS, 2012) to 0.377 mg/kg (Pain et al., 2010). These average levels are lower than those reported above for game birds killed with lead shot. However, as noted earlier, the lead contamination in large game varies widely; the 95th percentiles reported by Gerofke *et al.* (2018) in roe deer were 2.237 mg/kg close to the wound channel, 0.164 mg/kg in the saddle area and 0.064 mg/kg in the haunch. Maximum levels in individual samples can be far higher: Martin *et al.* (2019) reported maximum lead concentrations in lead-bullet-killed deer of 3442 mg/kg close to the wound channel, whilst Gerofke *et al.* (2018) reported a maximum concentration of 4728 mg/kg in this region in roe deer.

Therefore, it is possible that game-bird consumers might be consistently exposed to elevated lead levels, whereas consumers of large game killed with lead bullets might be exposed to both low levels of lead (below the EUML) and sometimes very elevated lead levels. The differences in health risk between these two potentially different patterns of exposure is not known. Butchery practices and the cuts of meat consumed will have a major impact on human lead exposure via large game hunted with lead bullets. Overall, the Agency concludes that, although the total quantity of lead in large game from bullets is potentially greater than the quantity of lead in small game from shot, this does not necessarily translate into greater human exposure from the former. It cannot be excluded that consumers of large game might sometimes be exposed to high lead concentrations, but the frequency of this occurrence and numbers of people impacted is unknown.

Blood lead levels

The most common and accurate method of assessing lead exposure is by analysis of lead in whole blood, which reflects recent lead exposures. Amongst hunters, exposure to lead can result from both hunting/shooting activities (the handling and use of lead ammunition) and the consumption of meat that contains ammunition-derived lead. The data on BLL increments from game meat consumption only (excluding hunting and shooting activities) are very limited. Whilst some data have indicated a small increase in BLL amongst high-level (non-UK) consumers and subsistence hunters, other studies have not identified an association of increased BLL with consumption of game meat. No UK-specific measured data on the impact

of game meat consumption on BLL have been identified. RAC, in its opinion on the EU proposal to restrict lead and its compounds (ECHA, 2022b), noted that, for adults (excluding pregnant women), exposure modelling showed only minor increases in BLL even in high-consumption scenarios; this was in agreement with the limited biomonitoring data, which did not show a clear association between game meat consumption and BLL. No reliable BLL measurements in children from hunter families are available. RAC noted that exposure modelling suggested up to medium increases in BLL were likely in children aged seven years and younger under high game meat consumption scenarios (hunter families).

Bioavailability of ammunition-derived lead

Information on the bioavailability of ammunition-derived lead is also limited, with considerable variation in those values that have been proposed, but is expected to be lower than that of lead in the general diet. Green and Pain (2012) predicted by regression modelling that the effect of ammunition-derived lead in adults was 39% lower than that expected for lead from non-ammunition sources. Taking into account the higher bioavailability of lead in the ordinary diet of children compared with adults, the authors used assumptions from the calculations on adults to estimate a value of 0.306 for the absolute bioavailability to children of lead derived from the cooked meat of wild birds. As discussed in the Background Document (Section 1.5.2), the modelling relied on Greenland data that were not necessarily representative of the UK and comprised some small group sizes, which increases the uncertainty associated with the model and the ensuing calculations. Furthermore, the relative contributions of lead exposure from hunting activities (non-dietary) and from exposure via game bird meat to the measured Greenland BLL were not considered. It seems reasonable to assume that those individuals who ate more game-bird meals were also the most frequent hunters and therefore that the impact of eating such meals on BLL could have been over-estimated.

Experimental studies indicate that the bioaccessibility (bioaccessible lead is soluble and available for absorption) and hence absolute bioavailability of ammunition-derived lead is impacted by the cooking method. Cooking under acidic conditions (e.g., in vinegar) has been reported to increase the absolute bioavailability of ammunition-derived lead (Mateo *et al.*, 2011, 2007; Schulz *et al.*, 2021), presumably because of an increased chemical transformation of metallic lead to lead salts that are more bioavailable. In an *in vitro* study in which human gastrointestinal digestion was simulated, the bioaccessibility of lead in partridge meat (hunted with lead shot) was 4.51 to 6.75% when cooked in wine or vinegar compared with 0.7% for uncooked meat. When meat from roe deer hunted with lead bullets was fed to growing pigs (as a model for humans, especially children), the absolute bioavailability of the lead cooked in water was 2.7%, whereas in meat that had been marinated in wine and vinegar before cooking it was 15%.

Potential health impacts of exposure to lead in game meat

LAG (2015b) and FSAS (2012) estimated the increase in dietary lead exposure that could result from the consumption of typical weekly quantities of wild game birds amongst UK high-consuming adults and children in different age groups. Both organisations considered that children aged 1.5 - 4.5 years who consumed two 30 g portions of game-bird meals per week could increase their dietary exposure to lead by up to 5 times. COT has used information on lead levels in different food sources (excluding game meat) from the Total Diet Study (FSA, 2014) and on the consumption of different foods from the DNSIYC to calculate margins of exposure (MOE) for infants (aged 0 to 12 months) and young children (1 - 5 years). In infants of 6 - 12 months and young children aged 1 - 5 years, the MOE for aggregated exposures (dietary, soil, dust, air) indicated that a risk at the population level and to some infants and young children could not be excluded, although risks from diet alone were small. EFSA (2010) did consider the contribution of lead in game meat to total dietary lead exposure and concluded this to be low overall, given the low levels of consumption of this meat in the European population. Nevertheless, amongst high-level infant and young child consumers of wild game, the MOE calculated by COT could be reduced.

Green and Pain (2012) concluded that the consumption of 0.4 – 0.7 game bird meals (size of meat meal portions of children aged 2.5 years and 6.9 years estimated from United States data combined with height and weight data for England) per week might be associated with a one-point decrease in the IQ of children. They then estimated the number of children less than 8 years of age in the UK who were at risk of incurring a one-point or more reduction in IQ as a result of exposure to ammunition-derived lead in game meat (Green and Pain, 2015b). They combined data from various sources, including the mean lead concentration in UK lead-shot game birds (Pain *et al.*, 2010), NDNS, FSAS (2012), their modelled bioavailability value and the EFSA BMDL value to estimate the at-risk population to be 3,800 (95% CI 3,050 – 4,374) to 28,710 (95% CI 12,684-47,846) children. This estimate assumed a constant rate of consumption of game meat throughout the year with lead levels that corresponded to the arithmetic mean calculated from six species of game bird; and some data were for all types of game, not just that shot with lead ammunition. Limitations in the studies used to model bioavailability are noted above and in the Background Document. The low estimate, which assumed a small meal size of 30 g, is used in the impact assessment.

The calculations for risks to adults indicated that a high level of game meat consumption would be needed to elicit the effects characterised by EFSA's BMDL values: 6.5 game bird meals of 200 g per week for a 10% increase in risk of chronic kidney disease (CKD) (129 to 338 people estimated to be at risk, depending on the assumptions made of the numbers of high-level game meat consumers in the UK) and 5.2 game bird meals per week for a 1% increase in systolic blood pressure (403 – 1060 people estimated to be at risk, again depending on the assumptions made of

high-level game meat consumers) (Green and Pain, 2015a, 2012). Again, these estimates assumed a constant rate of consumption of game meat throughout the year with lead levels that corresponded to the arithmetic mean calculated from six species of game bird; and some data were for all types of game.

Risk characterisation

The primary human-health risk addressed in the Background Document is that to **high-level consumers of game meat that has been shot with lead ammunition** (i.e., wild game). The highest consumers of game meat are hunters and their families. Employees of shoots are also likely to be high consumers.

In 2017, the FSA advised that consumption of lead-shot game meat, particularly that of small game, should be minimised because frequent consumption of this can expose consumers to potentially harmful levels of lead. The FSA highlighted that lead consumption is especially harmful, thus should be minimised, in vulnerable populations such as toddlers, children, pregnant women and women trying to conceive. The FSA also advised that there is no safe level of lead consumption.

Young children (≤ 7 years of age), including those exposed *in utero*, represent the most vulnerable population to health effects from chronic exposure to lead. This is because they are susceptible to neurotoxicity induced by lead and because their gastrointestinal absorption of lead is greater than that of adults. Therefore, the most relevant human-health impact of the proposed restriction is that on developmental toxicity in this population, i.e., the decrements in IQ that might ensue from lead exposure via the consumption of game meat. Given the potential for *in utero* exposure and also the possibility for lead to be transferred to infants in milk (albeit this is thought to be a minor source), **women of child-bearing age that consume game meat should be considered a vulnerable population.** RAC concluded that high-level game meat consumption resulted in a moderate-to-high risk for neurodevelopmental effects in children and at least a moderate risk for pregnant women.

Regarding CKD risk for adults, RAC noted that this was low, given the conservative nature of EFSA's BMDL and because of the need for long-term (> 5 years) constant exposure via highly contaminated game meat. RAC also concluded that some cardiovascular effects in adults were possible, but the level of adversity of these effects was not clear and hence the risks were low. Overall, therefore, RAC considered the risk to adults from the consumption of game meat hunted with lead ammunition to be **low**. The Agency concurs with this position.

As lead is a non-threshold neurotoxic substance, a qualitative risk assessment is appropriate according to REACH Annex I (paragraph 6.5). Risks to humans (primarily children and the offspring of pregnant women) from the consumption of game shot with lead ammunition cannot be excluded.

In addition to reductions in secondary exposure to lead through the consumption of lead-shot game, any measures to restrict the use of lead ammunition would reduce environmental contamination with lead and consequently other sources of secondary exposure through other food sources and water; and also direct exposure through hand-to-mouth and inhalation routes.

There are several uncertainties in the human-health assessment. These are listed in section 4.7.1.

4.1.3 Conclusion on risk

The identified risks for each use are described in the table below.

- The Agency concludes that for all identified uses there is a risk to the environment that is not adequately controlled.
- In addition, the consumption of game meat that has been hunted with lead shot or lead bullets presents a risk to vulnerable populations (young children and women of child-bearing age, given the potential for placental transfer of lead) that is not adequately controlled.

For the environment, the greatest risk (in terms of tonnage used, geographic scale and size of impact) is from the use of **lead shot**. There are no identified risk management measures that could be implemented to reduce the environmental emissions or to entirely remove the risk to human health from the use of lead shot for live quarry shooting.

Target shooting with lead shot uses a higher tonnage than live quarry shooting, and as the emitted lead shot remains on the surface of the ground there is a risk of primary poisoning to birds and livestock unless it is immediately collected. There are also risks to soil, water and to livestock via secondary poisoning if lead shot remains uncollected over longer periods of time.

The tonnages of lead used as **bullets** are much lower than the tonnages used as shot, and bullets do not pose a risk of primary poisoning. However, the Agency considers that for an equal tonnage of lead used as lead shot compared with lead bullets, a higher proportion of the bullet tonnage is relevant for secondary poisoning than the proportion of shot. In addition, because of feeding patterns and life history traits, the impact on population sizes of the larger raptor species that are exposed to bullet or bullet fragments has the potential to be greater than the impacts on population sizes of smaller raptor species that are exposed to lead shot.

There are no identified risk management measures that could be implemented to completely prevent environmental emissions or to entirely remove the risk to human health from live quarry shooting with bullets.

For target shooting with bullets it is possible to mitigate against the identified risks to soil, water and livestock by the implementation of appropriate risk management measures at shooting ranges. Evidence submitted indicates that, although many GB

target shooting sites have risk management measures in place already, some do not.

The tonnages of lead **airgun ammunition** for live quarry shooting and target shooting are uncertain. There are no identified risk management measures that could be implemented to completely prevent the environmental emissions from the use of lead airgun ammunition for live quarry shooting. For target shooting it may be possible to mitigate against the identified risks to soil, water and livestock by the implementation of appropriate risk management measures at shooting ranges.

Table 5 Summary of uses, risks and tonnages

Sector of use	Use #	Use title	Main risks identified	Annual use (tonnes per year)
Live quarry shooting	1	Live quarry shooting with shot	Primary and secondary poisoning of birds Risks to mammals (livestock, wildlife and companion animals) Risks to soil compartment Risks to water compartment Risks to humans via consumption of game meat	1,601
	2	Live quarry shooting with bullets	Secondary poisoning of birds Risks to mammals (wildlife and companion animals) Risks to humans via consumption of game meat	3
	3	Live quarry shooting with airgun ammunition	Primary and secondary poisoning of birds Risks to mammals (wildlife and companion animals)	1
Target shooting	4	Outdoor target shooting with shot	Primary and secondary poisoning of birds Risks to mammals (livestock and wildlife) Risks to soil compartment Risks to water compartment	5,359

	5	Outdoor target shooting with bullets	Risks to mammals (livestock and wildlife) Risks to soil compartment Risks to water compartment	112
	6	Outdoor target shooting with airgun ammunition	Primary and secondary poisoning of birds Risks to mammals (livestock and wildlife) Risks to soil compartment Risks to water compartment	12

4.2 Rationale for the scope of the proposed options

To propose a restriction under Article 69(1) of UK REACH, the Agency must demonstrate that there is risk that is not adequately controlled and that the proposed restriction is the most appropriate measure to manage that risk. The appropriateness of the proposed restriction is assessed on these **criteria**:

- **Effectiveness**: the restriction must be targeted to the effects or exposures that cause the risks identified, capable of reducing these risks to an acceptable level within a reasonable period of time, and proportional to the risk
- **Practicality**: the restriction must be implementable and manageable
- **Monitorability**: it must be possible to monitor the result of the implementation of the proposed restriction
- **Enforceable**: there must be a clear and efficient mechanism by which the enforcing authority can ensure compliance with the proposed restriction.

For each identified use, the Agency has considered a number of risk management options that could be implemented. These options included regulatory measures under UK REACH as well as other options, such as voluntary agreements. Each option has been considered for effectiveness, practicality, monitorability and enforceability. In addition, potential linkages or interactions between different risk management options have been considered.

The Annex 15 dossier that was published to support the public consultation identified several potential options for each of the uses (a 'long-list') (HSE, 2022). From this long-list, the Agency selected those options that were considered the most likely to be effective i.e., those considered to reduce or eliminate the risks identified for both the environment and human health (the 'shortlist'). Following the completion of the analysis of the risk management options on the shortlist, the options that the Agency

concluded would be effective and either fully or partially practicable, monitorable and enforceable were taken forward for further assessment in the impact assessment. The impact assessment includes a consideration of the costs and benefits of the options. Further information is provided in the Background Document.

4.2.1 Overview of the options that have been considered

Live quarry shooting with lead shot (Use 1)

The only option the Agency identified to reduce risks to both wildlife and human health that would be fully effective, practical, monitorable, and enforceable was a prohibition on the placing on the market and use of lead shot for live quarry shooting. The same conclusion was drawn by LAG (2015a) and (ECHA, 2021).

A full prohibition on the placing on the market and use of lead shot for live quarry shooting would result in a 100% reduction in the release of lead shot compared with the baseline and would therefore be effective in reducing future risks to the environment. Human exposure via game meat consumption would also be prevented as soon as the prohibition came into force.

Alternative ammunition to lead shot is readily available. The main UK organisations representing shooting interests have acknowledged that a switch is feasible and that non-lead alternatives perform effectively. These organisations have implemented a voluntary phase-out of lead shot for this use. Some GB supermarkets have also committed to only selling game meat from animals killed with non-lead ammunition. The existing prohibition of lead shot over wetlands throughout GB demonstrates that effective alternatives already exist and are in use now. Defining a transition time that allows sufficient volumes of non-lead alternative shot ammunition to be available on the market, and consideration of any necessary “use up” period, will be key to ensuring this option is practical.

Shotgun cartridges are labelled for sale for either target or live quarry shooting, as the shot pattern and load required are different for each activity, although the Agency understands that there is some crossover between the uses. Restricting both uses ensures that no crossover can take place. A prohibition on the placing on the market of shot cartridges for live quarry shooting and target shooting is monitorable as the suppliers of ammunition (wholesale and retail outlets) can be monitored directly. A monitorable prohibition on sales alone should be sufficient to determine the effectiveness of this option.

This option is enforceable by regulatory authorities as it involves control at the point of sale and compliance can be monitored remotely. Compliance visits could be carried out at relevant premises, either those identified as potentially non-compliant or on a spot-inspection basis. This restriction would also apply to imports of lead shot, since under REACH import is deemed placing on the market.

Given that this option has been determined as sufficiently effective, practical, monitorable and enforceable for this use, it has been taken forward into the socio-economic analysis.

Live quarry shooting with lead bullets (Use 2)

The only option the Agency has identified to reduce the risks to both the environment and human health that would be fully effective is a prohibition on the placing on the market and use of lead bullets for shooting live quarry. Secondary poisoning of wildlife and human exposure via game-meat consumption would be prevented as soon as the prohibition came into force.

For larger calibre bullets this option is considered practical because suitable non-lead alternatives are available on the GB market. However, this is currently impractical for certain small calibres as the alternatives are at an earlier stage of development and testing. For a restriction put in place across all calibres, a longer transition period might be granted to smaller calibre bullets to allow for sufficient time to develop more suitable alternatives. There is already a move to lead-free ammunition in GB, with the National Game Dealers Association committing that from July 2022 its members will not accept game shot with lead ammunition. Furthermore, with the in-progress EU restriction that proposes a prohibition on lead bullets for hunting, it is likely that more alternatives will be developed and brought to market over time.

During the development of the opinion, some complications have emerged around expanding and non-expanding ammunition, and how each is used. A restriction on the placing on the market of **all** lead-based bullets would not be possible, since they would still be required for indoor shooting (which is out of scope). The Agency is seeking further information during the public consultation on the different, lawful, uses of expanding and non-expanding ammunition; or ammunition which is intended solely for either live quarry shooting or target shooting.

Currently, it is understood that in GB the use of non-expanding bullets for shooting deer is already illegal, although this is not necessarily a requirement for other quarry.

It is possible that ammunition which remains on the market for indoor target shooting could be used for the pursuit of some live quarry. Hence it would not be possible to completely restrict the placing on the market of lead bullets solely “for live quarry shooting”. The Agency is seeking further information on this during the public consultation on the socio-economic assessment, to better determine any restriction and enforcement options.

Where a clear distinction between ammunition used solely for live quarry shooting or solely for target shooting can be drawn:

- A prohibition on the placing on the market of “bullets for live quarry shooting” would be monitorable as the suppliers of ammunition (wholesale and retail outlets) can be monitored directly. A monitorable prohibition on sales alone should be sufficient to determine the effectiveness of this option

- Similarly, this option would be enforceable by regulatory authorities, as it involves control at the point of sale and compliance can be monitored remotely. Compliance visits could be carried out at relevant premises, either those identified as potentially non-compliant or on a random basis.

However, whilst some ambiguity around the separation of uses between bullets for live quarry and target shooting remains, the monitorability and enforceability of this option appear less viable. As such, the Agency is seeking further information during the public consultation to fully assess this option.

Nonetheless, this was the only risk management option taken forward into the socio-economic analysis for this use.

Live quarry shooting with lead airgun ammunition (Use 3)

The only option that could reduce risks to the environment would be a prohibition on the use of lead airgun ammunition for live quarry shooting. However, there are no viable alternatives for many airguns (and which would not, inadvertently, give rise to potentially significant illegal use – see section 2.2.5.1) and lead airgun ammunition would still be available for sale for indoor use; therefore, a prohibition ban on use would not be practical, monitorable, or enforceable.

The Agency was therefore unable to identify a risk management option to be taken forward to the socio-economic analysis for this use.

Target shooting with lead shot (Use 4)

The only option the Agency identified to reduce risks to the environment that would be fully effective, practical, monitorable and enforceable was a prohibition on the placing on the market and use of lead shot for target shooting. A full prohibition on the use of lead shot for target shooting would result in a 100% reduction in release of lead shot and would therefore be effective in reducing the risks to the environment.

Alternative non-lead ammunition that performs efficiently is readily available. However, the use of lead shot cartridges is currently required by some sports' governing bodies (such as the International Olympic Committee (IOC)). A restriction with derogation would allow for identified, individual athletes to continue to train and compete with lead shot. The Agency considers the only derogation that would be practical is to allow a select number of athletes to continue to source and use lead shot. This is considered to be practical as these athletes are already identified annually by the relevant sporting bodies for the purposes of funding and training. The implementation of this derogation would mean that the restriction would not be fully effective in reducing risks to the environment. For example, risk to birds would remain, as spent lead shot would be present on the ground and could be ingested by birds. However, the Agency estimates that less than 1% of emissions currently occurring under the baseline would continue to occur under this option. If this derogation was implemented, a corresponding large reduction in the risk to crops or

grazing animals would also be expected, for instances where there is agricultural use within the site boundary. This derogation could be indefinite or time-limited. If time-limited, it could be paired with action to influence the governing bodies to change their rules to allow for a full restriction of lead shot in target shooting without undesired impacts on British athletes.

Shotgun cartridges are labelled for sale for target or live quarry shooting, as the shot pattern and load required are different for each type. A prohibition on the placing on the market of lead shot cartridges for target shooting is monitorable as the suppliers of ammunition (retail outlets) can be monitored directly. A monitorable prohibition on sales alone should be sufficient to determine the effectiveness of this option. However, as target shooting generally takes place on an organised basis involving either fixed or mobile locations, the operators of these ranges could check the shooters are not using lead shot cartridges. If a restriction was also implemented on the placing on the market and use of lead shot for live quarry shooting this would prevent any cross-over between uses.

The derogated athletes could be supplied directly by lead shot manufacturers, without general supply to the public. This method of supply to the athletes is considered to be the easiest way to monitor and enforce this derogation and is thus being investigated further.

This option is enforceable by regulatory authorities as it involves control at the point of sale. Compliance visits could be carried out at relevant premises, either those identified as potentially non-compliant or on a spot-inspection basis. Under the derogation, identified suppliers and athletes could be required to maintain records of the volumes of lead shot supplied/received and to provide this to the appropriate enforcement Agency on request. As the athletes would need to continue to be allowed to purchase and use lead shot to be able to participate in their sport, the Agency considers that compliance with the restriction would be very high.

Two risk management options were taken forward into the socio-economic analysis for this use: a prohibition on the placing on the market and use of lead shot for target shooting; and a prohibition on the placing on the market and use of lead shot for target shooting with a derogation for suppliers and athletes identified by the appropriate sporting body.

Target shooting with lead bullets

The only risk management option that the Agency considers effective, monitorable, practical and enforceable in principle is a prohibition on the use of lead bullets for target shooting with a derogation for sites with appropriate risk management measures. The Agency expects that in many cases, the existing measures are already in place, since they relate to the removal of lead for safety as specified in the NRA Range Design and Safety Handbook (NRA, 2022).

Risks to soil, water and livestock are expected to occur if lead bullets are left uncollected over longer periods of time. It is considered possible to mitigate against

the identified risks by the implementation of appropriate risk management measures at shooting ranges. Therefore, a derogation is proposed allowing the use of lead-containing bullets at ranges where action is taken to reduce the risks to the environment from this activity. Ranges would be required to notify the enforcing authority that action has been taken to reduce the environmental risks, and a list of notified ranges would be made publicly available.

A similar conclusion was drawn by ECHA (2022b). The use of lead bullets is currently required by some sports' governing bodies and so this derogation would allow athletes to continue to train and compete at shooting ranges that have the appropriate risk management measures in place.

Risk management measures are already recommended in the EU REACH registration dossier for metallic lead to ensure safe use, and the Agency anticipates that they will also be included in the full UK REACH registration dossier when it is submitted in due course. Further, as there are already requirements for bullet capture on ranges for safety reasons it is expected that nearly all ranges will have bullet capture and de-leading. This management of lead which could pose a risk to the environment around ranges is expected to be the main contributing factor in risk reduction. Responses to the GB call for evidence indicated that risk management measures achieving 90 % lead recovery are already in place at some shooting ranges in GB. Therefore, this appears to be a practical option.

Sites would need to demonstrate that they have considered relevant risks to the environment and document the actions they are taking to minimise those risks. Information regarding the identified risks and mitigations should be maintained and made available to enforcing authorities upon request. Guidance is expected to be produced to elaborate on the identified environmental risks and the actions that would likely be sufficient to reduce them, as it is expected to differ slightly depending on the individual range, operating conditions, frequency of shooting etc. This guidance may be part of an amendment or addition to existing industry guidance.

This could slightly increase the costs for some shooting ranges, as they would have to ensure they have considered, documented, and actioned the environmental risks and mitigations that have been identified. In practise, it is expected that the majority of ranges already have the appropriate risk reduction measure in place for the purposes of shooter safety, and simply need to ensure this is documented.

Practically, existing range management guidance, which is in place for safety, may go a significant way towards documenting risks to the environment and identifying how to address those risks – especially regarding de-leading.

This option is enforceable as checks could be made at sites for which notification has been made, determining whether they have documentation considering the environmental risks and mitigations in place to allow the continued use of lead bullets. Issues around which organisations would be responsible for enforcement would require further consideration, together with how the notification scheme would be operated.

This was the only risk management option taken forward into the socio-economic analysis for this use.

Target shooting with lead airgun ammunition

The only option that could reduce risks to the environment would be a prohibition on the use of lead airgun ammunition for target shooting. However, there are no viable alternatives for many airguns and ammunition would still be available for sale for indoor use. Therefore, a prohibition on use would not be practical, monitorable, or enforceable.

The Agency was therefore unable to identify a risk management option to be taken forward to the SEA for this use.

4.2.2 Rationale for modifying restriction options

A long-list of potential options was listed and included for consideration during development of the Annex 15 dossier resulting in the initial restriction proposal (HSE, 2022). Based on information supplied to us during the public consultation and comments received from the REACH Independent Scientific Expert Pool (RISEP), a shortlist of options was developed by selecting only those that the Agency considered were the most feasible and impactful. The options included in the short list are only those that have the potential to eliminate or reduce the risks identified for both the environment and human health (where relevant) for each use. Fiscal measures which were identified as options in HSE (2022) but not fully assessed at that time were included in the short list. An analysis of each of the options on the short list was undertaken for each use and is described in the Background Document, underpinned by information on uses, releases and availability of alternatives.

Since the publication of the Annex 15 dossier, receipt of information from the first public consultation, scrutiny by RISEP, and further stakeholder engagement, some of the options previously proposed have been modified.

Lead shot for target shooting

The option that would provide a fully effective removal of risks is a complete prohibition on the placing on the market and use of lead shot for target shooting. This was not considered practical as it would prevent a small number of athletes who perform at the highest level from training and competing with the lead shot that is required by the rules of the sport. In the Annex 15 dossier the Agency had included a proposal to derogate licensed sites for target shooting with lead shot where risk management was in place, in addition to licensing the placing on the market of lead shot and use by athletes.

In meeting with the relevant bodies that oversee outdoor target shooting and competitive shotgun shooting in GB, the Agency established that:

- approximately 50 shooters at any time may be required to continue shooting lead
- the total amount of lead used by these athletes annually is approximately 37 tonnes (0.6% of the amount of lead used for target shooting with lead shot)
- the locations used to shoot are spread across GB, depending on the needs of the individual athlete
- risk management measures suitable for capturing and collecting spent lead shot are not feasible at the vast majority of shooting sites, often because of the types of land over which shooting occurs.

It also became clear that a *licensing* scheme for sites and athletes was not required, and something much simpler could be established, relying on the vastly decreased use only by identified athletes, dispersed over a variety of sites, and the clear identification and management of athletes by competitive shooting governing bodies.

The proposal to license the sites has therefore been removed from the proposed restriction option for use of lead shot in outdoor target shooting as it is not considered practical. However, the proposed restriction still includes the sport's governing bodies specifying only certain athletes that are required to continue to shoot lead shot, to reduce the tonnages used and therefore the risk.

Lead in airgun ammunition

In the Annex 15 dossier, the use of airgun ammunition in live quarry shooting was incorporated within the use of small calibre bullets. Although identified as a separate use, the Agency did not have sufficient information to assess the options for use of airgun ammunition for target shooting. Instead, the options considered for target shooting with small calibre bullets were also considered to be appropriate for this use. In the Background Document the options to mitigate against risks from uses of lead airgun ammunition are now considered separately.

Lead airgun ammunition is used for live quarry and indoor and outdoor target shooting. A prohibition on the placing on the market of lead airgun ammunition *per se* cannot be considered as this would prevent sales for the indoor uses that are formally out of scope for consideration of a restriction. The only options therefore need to be focussed on the use, not the supply, of this ammunition. The Agency considers that any prohibition on the use of lead airgun ammunition in outdoor settings will be both unmonitorable and unenforceable, as the use takes place not only in formal shooting settings, such as ranges or field target sites, but also on private land, such as farmland and back gardens.

4.2.5 Further information about the proposed restriction

The Agency is not proposing to include additional labelling requirements for lead ammunition or to make the provision of information about the restriction compulsory at the point of sale. The Agency considers that other methods to promote the phase-out of lead ammunition and the use of alternatives would be more effective. This

could include, for example, direct engagement with shooting organisations, suppliers and users.

4.3 Justification for action

Some legally binding risk management measures are already in place in England, Wales and Scotland to mitigate the risks from the use of lead shot over wetlands in order to meet our commitments under the African-Eurasian Waterbird Agreement (AEWA, 1999). The wetland restrictions vary between England, Wales and Scotland and do not uniformly apply to all wetland habitats or protect wetland birds that feed in terrestrial habitats (such as grazing swans, geese and ducks) from ingestion of lead-shot pellets. There is also evidence from monitoring studies that compliance with the current restrictions on the use of lead shot over wetlands is low.

The UK is also a contracting party to the United Nations Environment Programme (UNEP) Convention on Migratory Species (CMS). The UK hosts 31 species that are included in CMS Appendix I or II, indicating that they are at high or moderate risk of primary poisoning from lead shot, and 10 Appendix I and II raptor species at high or moderate risk of secondary poisoning. Increased risk management of lead ammunition would reduce the risks to both GB bird populations and migratory species. The Conference of the Parties to CMS adopted the Guidelines to Prevent the Risk of Poisoning to Migratory Birds through Resolution 11.15 (Rev.COP13), which includes the recommendation to “Phase-out the use of lead ammunition across all habitats (wetland and terrestrial) with non-toxic alternatives [...] To reduce problems with monitoring, compliance and enforcement, such processes should not be partially restrictive”.

The main justifications for a **GB-wide restriction** are therefore:

- to ensure a harmonised high level of protection of the environment and human health to address the identified risks, which are common to England, Scotland and Wales
- to ensure free movement of goods within GB in line with the UK Internal Market through consistency of regulation; and
- to ensure a level playing field for everyone engaged in outdoor target shooting within GB.

A restriction under UK REACH would:

- allow effective control of both placing on the market and use of lead in ammunition in specified activities
- address risks to human health and/or the environment
- be applicable across GB through a single legislative change
- be subject to appropriate scrutiny throughout the legislative process and

- be subject to the REACH core principles of practicality, effectiveness, and enforceability

And additionally:

- increase compliance with the existing bans on some uses of lead shot to meet our commitments under the African-Eurasian Waterbird Agreement (AEWA, 1999)
- and fulfil the UK's obligations as a contracting party to the United Nations Environment Programme (UNEP) Convention on Migratory Species (CMS)

Hence, it is the recommended regulatory tool for tackling the risks presented by lead in ammunition.

4.4 Socioeconomic/Impact Assessment- summary

The Agency's socioeconomic analysis (SEA) investigates the impacts anticipated to arise from the proposed restriction. Section 2 of the Background Document outlines the full SEA.

4.4.1 Baseline

Table 6 below outlines the Agency's estimated annual releases of lead from each use. Further information on how the Agency has arrived at these figures may be found in section 1.4.3 of the Background Document.

Table 6 Estimated annual releases of lead from each use

Use	Annual lead ammunition use estimate (GB)	Annual lead emissions (GB, tonnes)
Live quarry shooting (LQS) with shot	54.2m cartridges	1,601
Live quarry shooting with bullets	0.7m small calibre bullets 0.2m large calibre bullets	2 (small calibre) 1 (large calibre)
Outdoor target shooting (TS) with shot	181.3m cartridges	5,359
Outdoor target shooting with bullets	13.0m small calibre	38 (small calibre)

	bullets 7.3m large calibre bullets	73 (large calibre)
Live Quarry and outdoor target shooting with airgun pellets	>16.9m	>13
Total	235.5m cartridges 21.2m bullets >16.9m airgun pellets	7,089

Notes: all figures rounded to the nearest tonne. Totals are calculated based on unrounded estimates and rounded to the nearest tonne, rather than summing individual rounded estimates.

These releases are used to construct the baseline within the Agency's SEA. In 2020, nine of the major UK shooting organisations announced a 5-year voluntary transition away from lead ammunition in live quarry shooting with shotguns. Additionally, certain supermarkets have committed to selling game meat shot only by lead-free cartridges. The Agency also understands that certain deer culls stipulate the use of lead-free bullets. Accordingly, the Agency anticipates some transition away from lead under the baseline, for LQS with shot and large calibre bullets. Certain research suggests this has been very limited to date. For instance, Green *et al* (2023) found that 94.0 % of the 235 pheasants from which shotgun pellets were recovered in 2022/23 had been killed using lead ammunition, compared to 99.5% in 2021/22 and 99.4 % in the 2020/21 season. Despite this, the Agency does expect some limited transition towards alternatives in these uses. In the absence of a sophisticated forecast, the Agency will decrease baseline annual emissions of lead from live quarry shooting with shot and large calibre bullets by an arbitrary 10% in the year 2025 onwards to account for some switch in demand to lead-free alternatives due to the voluntary measures. The quantities in table 2.2 do not include this 10% reduction in LQS with shot and large calibre bullets due to them being assumed to take place from 2025 onwards. Once accounting for a 10% decrease from 2025 onwards, the estimated annual emissions from LQS with shot and large calibre bullets become 1,441t and 1t², respectively. Estimated annual emissions in the other uses remain unchanged across the 20-year baseline.

In summary, the annual uses outlined in Table 6 are forecast over the 20-year time-period studied, with a 10% total reduction from 2025 onwards for live quarry shooting with shot and large-calibre bullets alone. Table 7 below outlines total estimated baseline lead emissions over the 20-year time-period studied (2024-2043):

² Due to rounding, this figure bullets appears to be the same as that prior to accounting for a 10% reduction in use from voluntary measures. Unrounded data is used in the Agency's analysis, with results presented in rounded form.

Table 7 Total estimated baseline lead emissions (20 years)

Use	Total estimated lead emissions, 2024-2043 (GB, tonnes)
Live quarry shooting with shot	29,000
Live quarry shooting with bullets	36 (small calibre) 25 (large calibre)
Outdoor target shooting with shot	107,200
Outdoor target shooting with bullets	770 (small calibre) 1,460 (large calibre)
Live Quarry and outdoor target shooting with airgun pellets	>260
Total	139,000 (3 significant figures)

In addition to this, a relatively small amount of non-lead ammunition is used. For shot, based on Blake International (Hurley, 2022) the Agency estimates that roughly 4% of shot currently used in the UK is non-lead, primarily steel. These data did not extend to bullets, but the Agency is aware that some shooters already transitioned to lead-free alternative ammunition, notably in large calibres where the technical barriers faced by small calibres do not exist.

4.4.2 Costs

This section will explore the societal costs of the interventions recommended on each use in section 2 of this opinion.

4.4.2.1 Costs of restriction on live quarry shooting with lead shot

When modelling the impacts of restriction on the shot uses, the Agency used the ratio of tonnage releases from LQS versus TS (23:77) to apportion impacts where relevant. For instance, where a restriction on the use of lead shot requires the purchase of new shotguns, the Agency assumes 23% of the total cost of new shotguns to be attributable to a restriction on LQS, and 77% attributable to TS. This assumption is necessary to circumvent certain data gaps, such as the exact share of shotguns owned that are attributed to each use. As such, the Agency assumes that the share of shotguns owned for LQS and TS equal the share of total shot emissions that each use makes up.

The Agency has identified and monetised the following costs that are likely to arise from restricting the use of lead shot in LQS:

- Shooter substitution costs

- Costs to manufacturers
- Climate impacts
- Enforcement costs

4.4.2.1.1 Shooter substitution costs

The Agency anticipates that, under a restriction on LQS with lead shot, a variety of costs would occur directly to shooters in moving away from lead shot to alternative shot. These costs can be classified as either one-off or on-going costs.

The Agency assumes that all shotguns in current use that can use steel shot do use it in the event of restriction. Steel shot has a significantly lower unit price than bismuth shot (and slightly lower than lead shot), in addition to performing similarly to lead. As such, the Agency does not see a rationale for a shooter choosing bismuth shot if they are able to use steel in their gun(s).

The Agency assumes that 73% of shotguns in use can instantly switch to (standard) steel shot without modification or re-proof. This is based on the results of the GunsOnPegs & Lycetts 2022 census [personal communication Guns on Pegs], seen by the Agency, where they find that that 73% of game shooters surveyed 'do not need to make any equipment changes in order to use steel shot'. Additionally, the Agency assumes that a further 5% of shotguns in use could use steel shot following modification. This is based on the BSSC consultation response (Organisation #100). More information on this assumption can be found in section 2.6.1.1.1 of the Background Document.

Based on these assumptions, the Agency anticipates the restriction to induce the following one-off costs for shooters:

- The cost of purchasing a new shotgun in order to shoot alternatives to lead shot. The Agency estimates this cost to total £76.7m in present value (PV) terms.
- The cost of modifying their existing shotguns(s) in order to shoot alternatives to lead shot. The Agency estimates this cost to total £3.6m in PV terms.
- Any re-proof that may be required after such modifications. The Agency estimates this cost to total £0.5m in PV terms.

In terms of on-going costs, shooters may face:

- Costs due to more expensive alternative ammunition. The Agency estimates this cost to total £32.1m in PV terms.

Section 2.6.1.1.1 of the Background Document contains full detail on the methodology and assumptions used to estimate the substitution costs to shooters. Totalled across the 20-year appraisal period, the Agency estimates these costs to amount to **£112.9m** in PV terms.

4.4.2.1.2 Costs to manufacturers

(Blake International, 2022 Organisation #132) (Hurley, 2022) examine and audit the UK shotgun cartridge manufacturing industry to estimate the costs of a complete transition away from lead shot. They conclude that such a transition would cost manufacturers an estimated £21.1m. This is broken down into the following costs:

- 1) Cartridge filling machinery: £6.675m
- 2) Injection moulding machinery: £2.98m
- 3) Buildings and infrastructure: £2.95m
- 4) Dies and Tools: £1.865m
- 5) Working capital expansion: £6.42m
- 6) Site decontamination: £0.2m

Further detail on these costs can be found in section 2.6.1.1.2 of the Background Document.

The Agency weights the total estimated cost of £21.1m by the share of shot emissions attributable to LQS: 23%. This results in an estimated manufacturer cost from a restriction on LQS with shot of £4.9m in undiscounted terms and **£4.5m** in PV terms. The Agency assumes this cost to be accrued uniformly across the 5-year transition period, equalling £0.97m on an annual basis (undiscounted).

4.4.2.1.3 Climate impacts

The Agency uses emissions factors (EF) provided by the Bureau of International Recycling (BIR, (2008)) to estimate the resulting change in greenhouse gas (GHG) emissions from a transition from lead shot to alternatives.

The worst-case scenario in terms of climate impacts is one where lead shot, under the baseline, is domestically produced entirely from recycled lead, and under a restriction steel shot is produced from 100% primarily produced steel imported from afar (presumed to be China based on information submitted by Blake International, 2022 Organisation #132) (Hurley, 2022). The Agency cannot validate that this is the likely reality of a restriction but will use the scenario as a conservative assumption.

Under this worst-case scenario, the Agency estimates that a restriction will result in 2,239t CO₂/annum compared to 286t CO₂/annum under the baseline (from 2025 onwards). This equals an annual addition of 1,954t CO₂, roughly equal to the average annual carbon footprint of 210 UK citizens (WWF, 2023). Using the BEIS (2021) carbon values for the corresponding year, the climate impacts from restriction can be estimated at £9.4m across the 20-year appraisal period in undiscounted terms, and **£6.2m** in PV terms. Details of how the Agency has arrived at this estimate are in section 2.6.1.1.3 of the Background Document.

4.4.2.1.4 Enforcement costs and compliance-check costs

Based on discussions with Environment Agency enforcement experts, the Agency expects that the necessary compliance checks under a restriction would be less than **£50,000** (PV) across the 20-year appraisal period. This cost is based on the FTE requirements anticipated by the Agency to undertake the relevant compliance checks across GB. In the event of non-compliance, further action will likely be required which would see this cost rise. In any case, it is certainly not considered to be a significant cost relative to the others identified.

4.4.2.1.5 Totals and summary statistics

In line with the analysis presented above, the Agency estimates the societal costs of restriction on lead shot for LQS to be £148.7m across the 20-year appraisal period. This is **£123.7m** in PV terms, resulting in an average annual discounted cost of **£6.2m**. The Agency estimates that this restriction, with a 5-year transition period, would avoid the release of roughly 21,600t of lead across the same 20-year appraisal period. This results in a cost-effectiveness ratio of **£5,700/t** Pb avoided. The tonnage proxy within this cost-effectiveness ratio represents the following risks associated with this use:

- Birds (primary poisoning)
- Birds (secondary poisoning)
- Ruminants/Grazing animals
- Mammalian scavengers/companion animals
- Soil contamination
- Water contamination
- Neurodevelopmental impacts in children
- Chronic Kidney Disease impacts
- Cardiovascular impacts.

4.4.2.2 Costs of restriction with derogation on target shooting with lead shot

The Agency has identified and monetised the following costs that are likely to arise from a derogated restriction on the use of lead shot in LQS:

- Shooter substitution costs
- Costs to manufacturers
- Climate impacts
- Enforcement costs.

The Background Document also assesses the impacts of a non-derogated (blanket) restriction on this use. The outcomes of that analysis are summarised in section 4.4.7 of this opinion.

4.4.2.2.1 Shooter substitution costs

As in 4.4.2.1.1, the Agency anticipates that, under a derogated restriction on TS with lead shot, a variety of costs would occur directly to shooters in substituting away from lead shot to alternative shot. These costs can be classified as either one-off or on-going costs. The same assumptions apply here as those outlined in section 4.4.2.1 of this opinion (explored in further detail in section 2.6.1.1.1 of the Background Document).

In terms of one-off costs, shooters may face:

- The cost of purchasing a new shotgun in order to shoot alternatives to lead shot. The Agency estimates this cost to total £241.1m in PV terms.
- The cost of modifying their existing shotguns(s) in order to shoot alternatives to lead shot. The Agency estimates this cost to total £12.0m in PV terms.
- Any re-proof that may be required after such modifications. The Agency estimates this cost to total £1.7m in PV terms.

In terms of on-going costs, shooters may face:

- Costs due to more expensive alternative ammunition. The Agency estimates this cost to total to £120.4m in PV terms.

Section 2.6.1.3.1 of the Background Document contains full detail on the methodology and assumptions used to estimate the substitution costs to shooters. Totalled across the 20-year appraisal period, the Agency estimates these costs to amount to **£375.2m** in PV terms.

4.4.2.2.2 Costs to manufacturers

As in 4.4.2.1.2, the Agency apportions the share of manufacturer costs outlined by Blake International (2022) by the share of shot emissions attributable to TS: 77%. This results in an estimated manufacturer cost from a derogated restriction on TS with shot of £16.2m in undiscounted terms and **£15.2m** in PV terms. The Agency assumes this cost to be accrued uniformly across the 5-year transition period, equalling £3.2m on an annual basis (undiscounted).

The Agency assumes that the cost to manufacturers under the derogated restriction proposed to be equal to those anticipated under a non-derogated restriction. More discussion on this assumption can be found in section 2.6.1.3.2 of the Background Document.

4.4.2.2.3 Climate impacts

Using the same methodology as in 4.4.2.1.3, the Agency estimates the worst-case annual increase in carbon emissions attributable to a derogated TS restriction to equal 7,905t CO₂. This is roughly equal to the average annual carbon footprint of 850 UK citizens (WWF, 2023). Using the BEIS (2021) carbon values for the corresponding year, the climate impacts from restriction can be estimated at **£37.8m** across the 20-year appraisal period in undiscounted terms, and **£25.1m** in PV terms. Details of how the Agency has arrived at this estimate are in section 2.6.1.3.3 of the Background Document.

4.4.2.1.4 Enforcement costs

Based on discussions with Environment Agency enforcement experts, the Agency estimates that the necessary compliance checks under a blanket restriction would cost ~£65,800 across the 20-year appraisal period. The Agency does not anticipate a derogation to require significant additional resource in burden in terms of enforcement but will assume this impact to arbitrarily equal £100,000 (undiscounted) across the 20-year appraisal period to allow for additional resource that may be required. The Agency assumes this total to be annualised from 2029, when the proposed restriction would be implemented, equalling **£66,900** in PV terms.

4.4.2.1.5 Totals and summary statistics

In line with the analysis presented above, the Agency estimates the societal costs of a derogated restriction on lead shot for TS to be £506.7m across the 20-year appraisal period. This is **£415.5m** in PV terms, resulting in an average annual discounted cost of **£20.8m**.

The Agency estimates that this restriction, with a 5-year transition period, would avoid the release of circa 79,800t of lead across the same 20-year appraisal period. This results in a cost-effectiveness ratio of **£5,200/t** Pb avoided. This is a more favourable cost-effectiveness ratio when compared to that of a non-derogated restriction. The tonnage proxy within this cost-effectiveness ratio represents the following risks associated with this use:

- Birds (primary poisoning)
- Birds (secondary poisoning)
- Ruminants/Grazing animals
- Mammalian scavengers/companion animals
- Soil contamination
- Water contamination.

4.4.2.3 Costs of restriction on live quarry shooting with large calibre (LC) lead bullets ($\geq 6.5\text{mm}$)

The Agency considers the data generally available on this use, in addition to that received in the consultation, to be considerably weaker than that of the shot uses. This is also the case for small calibre bullets and airgun pellets, discussed in sections 4.4.2.4 and 4.4.2.5, respectively. This is likely due to proportionality, whereby these uses comprise a smaller share of the total emissions within scope of this restriction proposal. As such, stakeholders have perhaps tailored their efforts accordingly. The Agency has sought to fill data gaps wherever possible, but significant gaps remain despite this, leading the Agency to prefer to take a semi-quantitative approach to examining impacts.

The Agency has identified the following costs that may occur under a restriction on LQS with LC lead bullets:

- Ammunition substitution cost
- Enforcement cost

Based on engagement with GTA, the Agency considers LC alternatives to be suitable for existing rifles in use without modification. This in turn means that new rifles should not need to be purchased to use alternatives to lead. Similarly, according to the GTA, civilian centrefire is typically produced outside of the UK, meaning any manufacture costs of a LQS restriction with LC bullets should fall beyond the geographic scope of this restriction. Climate impacts have not been considered; alternative bullets are made from a variety of different metals such as tin, zinc and copper, each with their own respective emissions factors. In any case, the reduction in use of lead from intervention in bullets will comprise a very small share of that of shot, meaning that any climate impacts are considered to be insignificant when compared to those of shot intervention.

4.4.2.3.1 Ammunition substitution costs

The Agency undertook desktop research to estimate the average price of large and small calibre bullets made from lead and from lead-alternatives. Information on this research can be found in section 2.6.3.1.1 of the Background Document. Using this data, and the estimated quantities of large calibre lead bullets used annually, the Agency estimates that a restriction on this use would result in an ammunition substitution cost of **£3.5m** in undiscounted terms, and **£2.4m** in PV terms.

4.4.2.3.2 Enforcement costs

Based on discussions with Environment Agency enforcement experts, the Agency expects that the necessary compliance checks under a restriction would be less than **£50,000** (PV) across the 20-year appraisal period. This cost is based on the FTE requirements anticipated by the Agency to undertake the relevant compliance checks across GB. In the event of non-compliance, further action will likely be required which would see this cost rise. In any case, it is certainly not considered to

be a significant cost relative to the others identified.

4.4.2.3.3 Totals and summary statistics

Combining these two costs, the Agency estimates that a restriction on LQS with LC lead bullets would result in costs of **£3.5m** totalled across the 20-year appraisal period. Once discounted, this is **£2.4m**. The Agency estimates that such a restriction would avoid the release of **21t** of lead across the 20-year appraisal period, resulting in a cost-effectiveness ratio of **£89,700/t** lead avoided. The tonnage proxy within this cost-effectiveness ratio represents the following risks associated with this use:

- Birds (secondary poisoning)
- Mammalian scavengers/companion animals
- Neurodevelopmental impacts in children
- Chronic Kidney Disease impacts
- Cardiovascular impacts.

The Agency advises caution when interpreting the analysis above. Firstly, >99% of the monetised cost estimate pertains to the ammunition substitution cost, which:

1. Is based on less reliable price data than that of the shot cartridge analysis—a wider variety of bullet calibres are in use than shot bore sizes, which introduces greater uncertainty when generalising prices into a single mean value.
2. Assumes that the relative price differential remains constant across the 20-year time-period of appraisal. Prices may fluctuate during this period.

These considerations mean that the above analysis may significantly change if assumptions around bullet prices change.

4.4.2.4 Costs of restriction on live quarry shooting with small calibre (SC) lead bullets (<6.5mm)

The Agency has identified the following costs that may occur under a restriction on LQS with SC lead bullets:

- Ammunition substitution cost
- Rifle re-barrelling cost
- Costs to manufacturers
- Enforcement cost
- Impacts from worse performing alternatives

Unlike with large calibre rifles, the use of alternatives in small calibre rifles requires the rifles to be re-barrelled. This is due to rifles requiring a new twist rate in the barrel to adjust for ballistics of alternative metals with different densities to lead. This

impact becomes relevant below a certain calibre, which the Agency estimates to be roughly 6.5mm. This, in part, forms the rationale for the 6.5mm small calibre-large calibre dichotomy.

Additionally, through engagement with the GTA the Agency understands that the UK domestically produces small calibre rimfire ammunition for civilian use, which is not considered to be the case for centrefire ammunition (both small and large calibre), which are imported into the UK. As such, a transition away from lead is assumed to impose some cost on manufacturers.

Climate impacts have not been considered; alternative bullets are made from a variety of different metals such as tin, zinc and copper, each with their own respective emissions factors. In any case, the reduction in use of lead from intervention in bullets will comprise a very small share of that of shot, meaning that any climate impacts are considered to be insignificant when compared to those of shot intervention.

4.4.2.4.1 Ammunition substitution costs

As mentioned in 4.4.2.3.1, the Agency undertook desktop research to estimate the average price of large and small calibre bullets made from lead and from lead-alternatives. Information on this research can be found in section 2.6.3.1.1 of the Background Document. Using this data, and the estimated quantities of large calibre lead bullets used annually, the Agency estimates that a restriction on this use would result in an ammunition substitution cost of **£0.3m** in undiscounted terms and **£0.2m** in PV terms.

4.4.2.4.2 Rifle re-barrelling cost

SC rifles will require re-barrelling to amend the twist rate in order to use lead-free bullets. Rifle re-barrelling occurs under the baseline due to general wear of the gun. The frequency of such re-barrelling depends on how often the rifle is used. For instance, rifles used for LQS are likely to be re-barrelled far less frequently on average than those used for TS, as more rounds are typically fired from a TS in a given time period.

The Agency assumes that under the baseline, LQS rifles are re-barrelled on average every 10 years. Through personal communications, the GTA has confirmed this to be a reasonable assumption.

Based on personal communications with a gun vendor, the Agency assumes that the cost of re-barrelling and subsequent re-proofing of a rifle to cost roughly £1,200.

Once accounting for the fact that rifles are periodically re-barrelled under the baseline (see section 2.6.3.2.2 of the Background Document for the full analysis), the Agency estimates the additional re-barrelling cost from restriction to equal **£0.9m** in present value terms (£0 prior to discounting, due to this constituting the transfer of a cost across time periods rather than an entirely new cost).

4.4.2.4.3 Manufacturer costs

Through engagement with the GTA, the Agency understands that the UK civilian rimfire manufacturing industry is still in the process of trying to develop a lead-free .22 rimfire bullet with satisfactory performance. They state that in the event of restriction, they would need to review the decision around continued manufacture in the UK vs relocation.

Due to limited data, the Agency is unable to quantify the costs to manufacturers of a restriction on the use of SC lead bullets for LQS or conclude on the magnitude of impacts. An EU restriction may induce many, or even all of these impacts, under the baseline if the EU market comprises a significant enough share of UK rimfire manufacturers' total sales. For instance, if, say, 80% of .22 rimfire bullets produced were exported to the EU, an EU restriction would presumably trigger the additional research and development or cause the seller to leave the market, as may happen under a GB restriction. If this is the case, it can reasonably be assumed that the costs attributable to a GB restriction are negligible. If this is not the case, manufacturer costs can be attributed to a GB restriction. Here, foregone producer surplus is likely to ensue if manufacturers choose to exit relevant markets (and in-turn, sellers further down the supply chain), which would also induce foregone consumer surplus for consumers and any wider impacts related to an inability to continue this use, such as limitations to pest control. If manufacturers do not exit the market, they may invest more in research and development of lead-alternatives than they would have under the baseline.

4.4.2.4.4 Enforcement costs

Based on discussions with Environment Agency enforcement experts, the Agency expects that the necessary compliance checks under a restriction would be less than **£50,000** (PV) across the 20-year appraisal period. This cost is based on the FTE requirements anticipated by the Agency to undertake the relevant compliance checks across GB. In the event of non-compliance, further action will likely be required which would see this cost rise. In any case, it is certainly not considered to be a significant cost relative to the others identified.

4.4.2.4.5 Impacts from worse performing alternatives

As outlined during section 2.2.4 of the Background Document, current alternatives available for this use are considered by the Agency to be worse performing. Concerns are particularly centred around accuracy at longer ranges and additional noise when compared to current sub-sonic SC lead bullets.

SC bullets are used in pest control, which is highly dependent on the ability to stealthily and accurately shoot the target animal. With less accurate and super-sonic ammunition, the ability to control pests may be affected, having several potential

undesirable impacts including to the environment. Other pest control measures exist, but it can be assumed that these are less effective, accessible, cost-effective etc. for the given use, otherwise they would already be used instead of ammunition. The Agency is unable to quantify this impact.

4.4.2.4.6 Totals and summary statistics

Combining these three monetised costs, the Agency estimates that a restriction on LQS with SC lead bullets would result in total costs **£1.1m** in PV terms. This does not include any foregone producer surplus for manufacturers and sellers, and the resulting foregone consumer surplus, nor the impacts from worse performing alternatives (such as implications for pest control).

The Agency estimates that such a restriction would avoid the release of **27t** of lead across the 20-year appraisal period, resulting in a cost-effectiveness ratio of **£41,400/t** lead avoided. The tonnage proxy within this cost-effectiveness ratio represents the following risks associated with this use:

- Birds (secondary poisoning)
- Mammalian scavengers/companion animals
- Neurodevelopmental impacts in children
- Chronic Kidney Disease impacts
- Cardiovascular impacts.

The Agency notes that this cost-effectiveness ratio reports a societal lower cost/tonne for restriction than that of LQS with LC bullets. In practice, the Agency anticipates that a restriction on LQS with LC would be a more cost-effective intervention than that of SC bullets. Cost-effectiveness (and any quantitative analysis) is limited by the extent to which parameters can credibly be estimated. The cost-effectiveness ratio for a restriction on SC lead bullets appears more favourable because:

1. Not all relevant costs have been monetised, which is not the case for LC bullets, and
2. As outlined in 4.4.2.3.3, the estimated costs of a LC lead bullet restriction depend almost entirely on the assumption that the current price differential will hold throughout the full 20-year appraisal period. The Agency has maintained this assumption in the absence of evidence to suggest the contrary, but it is plausible that the relative price of lead-free bullets will fall once they are more widely adopted. However, the current price differential for SC bullets appears less significant, and it also constitutes a smaller share of total costs, meaning this assumption has less ability to undermine analysis.

For these reasons, the Agency advises caution when relying solely on quantitative summary statistics to consider the case for restriction in these uses. The Agency

considers the socioeconomic case for restriction on these two uses **to be weaker than on the shot uses, with the socioeconomic case for restriction on SC lead bullets to be weaker than that of LC lead bullets**. This is not fully conveyed in the partial monetisation of costs alone.

4.4.2.5 Costs of restriction with derogation on outdoor target shooting with large and small calibre bullets

As discussed in section 2.6.3.3 of the Background Document, the Agency considers 95% of outdoor rifle ranges to be recovering their spent lead under the baseline.

Under the case of restriction with a derogation for sites with adequate de-leading in place (RMMs), the Agency anticipates the following societal costs to be incurred:

- 1) Administrative and enforcement costs
- 2) Range compliance costs

4.4.2.5.1 Administrative and enforcement costs

This option would require the Environment Agency to work with the appropriate shooting organisations (e.g., the NRA) to expand the existing range safety guidance with respect to environmental risks and how to address them. The updated guidance would be made available to shooting ranges, helping them identify and address the risks that may be present on their sites, as part of the notification requirement.

Ranges that do not notify, or have appropriate environmental risk reduction measures in place, would be unable to use lead ammunition on their range.

In the absence of relevant data, the Agency will assume amending this guidance will cost £1000 in foregone time from NRA and Environment Agency staff.

There are likely be additional costs to the sites in relation to:

- Notifying
- Becoming familiar with the updated guidance
- Ensuring appropriate action is being taken to reduce environmental risk

However, these are assumed to be negligible since:

- The notification process is not intended to be onerous, and
- In many cases the actions required to manage environmental risk (as reflected in the updated guidance) are already being conducted for the purpose of shooter safety.

The NRA notes that sites which de-lead currently recover 100% of spent bullets based on existing protocols, and that 95% of sites already de-lead their ranges – removing this lead from the environment. As such, the Agency does not consider this to be burdensome, rather a formal establishment of what is already in place.

Further information relating to these assumptions will be gathered during the SEA consultation period.

The regulator will also be required to check that such standards are in place over time. Based on conversations with Environment Agency enforcement experts, the Agency considers the required enforcement to cost **£104,000** over the 20-year appraisal period in undiscounted terms, and **£73,800** in PV terms.

As such, the total administrative and enforcement costs are estimated at **£105,000** in undiscounted terms and **£74,800** in PV terms.

4.4.2.5.2 Range compliance costs

Compared to the baseline, the Agency estimates that this option would result in an additional 3.75 ranges that would be required to use contractors to de-lead their ranges. Details on how the Agency has estimated this can be found in section 2.6.3.3.2 of the Background Document.

In the absence of data on current frequency and cost of de-leading, the Agency will assume this to occur on an annual basis on average, costing £10,000 per range. In this case, the annual additional de-leading cost constitutes £37,500 per year, totalling **£675,000** across the 20-year appraisal period in undiscounted terms. Once discounted, this is estimated at **£477,900**. The Agency will be seeking to verify this cost assumption during the SEA public consultation.

4.4.2.5.3 Totals and summary statistics

In total, the PV costs of this option are estimated at **£0.6m**. It would entail the recovery of the estimated 5% of quantity of bullets from this use that are currently not recovered, estimated to be 100t. As such, the cost-effectiveness ratio of this option is estimated at **£5,500/t** lead avoided. The tonnage proxy within this cost-effectiveness ratio represents the following risks associated with this use:

- Ruminants/grazing animals
- Soil contamination
- Water contamination.

It should be noted that this cost-effectiveness ratio is calculated using several arbitrarily assumed costings, so its use is limited when compared to the more robust findings in the analysis of shot restrictions. The Agency is seeking to validate its assumptions during the SEA consultation period.

4.4.2.4 Airgun intervention (both uses)

As outlined during the options analysis, the Agency has not identified any option for managing the risk from this use that would be monitorable and enforceable. As such, the Agency does not recommend restriction on this use, and will not provide further socioeconomic analysis on it within this dossier.

4.4.5 Benefits

The benefits of restriction are the reductions in risk associated with the emissions of lead from each use. Such benefits are difficult to quantify and monetise; because of this, the Agency primarily adopts a cost-effectiveness framework with tonnage of lead released used as a proxy for avoided risk. The Agency has nonetheless attempted to monetise the benefits of restriction. For the shot uses, the Agency has been able to partially monetise benefits. This is not the case for the bullet uses, where a fully qualitative assessment has been undertaken. This is because a quantitative risk assessment was not undertaken for this use. No assessment of benefits has been undertaken for the airgun uses as no monitorable or enforceable option was identified in the Background Document.

4.4.5.1 Benefits of a restriction on LQS with lead shot

As summarised in Table 1 of the Background Document, the environmental risks existing from this use are to:

- Birds (primary poisoning)
- Birds (secondary poisoning)
- Ruminants/Grazing animals
- Mammalian scavengers/companion animals
- Soil
- Water.

The Agency has monetised the benefit of avoided primary poisoning to terrestrial birds under a restriction of this use. The benefits of avoiding the other identified risks (including primary poisoning of birds beyond terrestrial) are not monetised largely due to no quantitative risk assessment having been undertaken. Uncertainty still remains within the Agency's monetised benefits assessment of the avoided primary poisoning to terrestrial birds, with full details outlined in section 2.6.5 of the Background Document.

The main human health risk is to young children (≤ 7 years of age), including those exposed *in utero*:

- Neurodevelopment impacts

A decrease in IQ by one point cannot be measured or attributed on an individual basis, but the COT (2016) noted that a downward shift in the distribution of IQs would have an impact at a population level.

In adults, the critical effects of chronic lead exposure are:

- Increased incidence of chronic kidney disease (CKD)
- Cardiovascular effects.

Because of the need for long-term constant exposure via highly contaminated game meat for impacts on CKD to manifest and the lack of clarity on how potential cardiovascular effects translate to adversity, the risks for adults are presumed to be low.

The Agency has monetised the benefit of reduced risk of neurodevelopment impacts in children and avoided cases of CKD but has been unable to quantify cardiovascular effects.

To monetise the avoided primary poisoning to terrestrial birds, the Agency undertook a benefits transfer based on Carson *et al.* (2003). Details of the Agency’s approach can be found in section 2.6.5.1.2 of the Background Document. The Agency estimates the benefits of avoided primary poisoning to terrestrial birds to equal **£154.9m** across the 20-year appraisal period in PV terms. This value is used as a proxy for the environmental benefits of restriction and is considered a conservative estimate by the Agency. The Agency anticipates the true societal benefits of restricting this use to exceed this monetary estimate; the estimate is based only on one of several environmental benefits of restriction.

In terms of human health benefits, the Agency has monetised the benefit of avoided neurodevelopment risk in children, as well as avoided CKD cases. IQ points foregone due to exposure to lead in game meat has been used as a proxy for neurodevelopmental risk, which in turn has been monetised based on an IQ-earnings approach. For CKD, the Agency has taken a QALY approach. The Agency has estimated the PV benefits of restricting this use in terms of avoided IQ loss and avoided cases of CKD at **£26.2m** and **£25.3m**, respectively. Section 2.6.5.2 of the Background Document provides full information on the Agency’s approach to monetising this impact. Conservative assumptions were made by the Agency when conducting this analysis. Such assumptions are necessary given the large uncertainty in the number of cases of CKD avoided, especially given that the overall risk to adults from exposure to lead in game meat is considered to be low.

Table 8 Summary of benefits: restriction on lead shot in LQS

Description of benefit	Type of benefits	PV benefit (20yrs)
Avoided bird deaths via primary poisoning	Environmental	£154.9m
Avoided bird deaths via secondary poisoning	Environmental	N/Q
Avoided sub-lethal effects in birds (suffering in poisoned	Environmental	N/Q

birds who do not die from primary or secondary exposure)		
Avoided risk to other wildlife, namely ruminants/grazing animals and mammalian scavengers/companion animals.	Environmental	N/Q
Avoided soil contamination	Environmental	N/Q
Avoided water contamination	Environmental	N/Q
Avoided neurodevelopmental impacts (proxied by avoided IQ loss)	Human health	£26.2m
Avoided increased incidence in CKD	Human health	£25.3m
Avoided cardiovascular effects	Human health	N/Q
Total		£206.4m

4.4.5.2 Benefits of a restriction with derogation on TS with lead shot

The set of environmental benefits that would arise from a derogated restriction on TS with lead shot are the same as those for a LQS restriction. No human health benefits are considered because exposure through game meat shot with lead is not relevant to this use, however, this restriction would reduce environmental contamination with lead and consequently other sources of secondary exposure through other food sources and water, and direct exposure through hand-to-mouth and inhalation routes.

The same methodology used to estimate environmental benefits is applied here, with the benefits weighted for the share of total annual shot emissions that would be prevented as a result of a derogated restriction on this use. The Agency estimates that the environmental benefits (in terms of avoided primary poisoning of terrestrial birds) of a derogated restriction on TS with lead shot are **£580.4m** in PV terms. As discussed in 4.4.5.1, this monetised estimate only comprises one of several environmental benefits of restriction. Table 9 summarises the benefits from a derogated restriction on this use, with the monetised estimate provided in PV terms.

Table 9: Summary of benefits: derogated restriction on lead shot in TS

Description of benefit	Type of benefits	PV benefit (20yrs)
Avoided bird deaths via primary poisoning	Environmental	£580.4m
Avoided bird deaths via secondary poisoning	Environmental	N/Q
Avoided sub-lethal effects in birds (suffering in poisoned birds who do not die from primary or secondary exposure)	Environmental	N/Q
Avoided risk to other wildlife, namely ruminants/grazing animals and mammalian scavengers/companion animals.	Environmental	N/Q
Avoided soil contamination	Environmental	N/Q
Avoided water contamination	Environmental	N/Q
Total		£580.4m

The Agency estimates that this derogated restriction, whereby individual athletes as identified by the appropriate sporting body continue to use lead shot in their training, would result in ongoing annual emissions of 37 tonnes of lead. In the event of a blanket restriction, 100% of emissions from this use would be eliminated. The Agency-estimated PV benefits of this option are **£584.4m**. This is greater than the benefits of the recommended option, but the benefit-cost and cost-effectiveness ratios of this approach are less favourable due primarily to the impact it would have on GB sporting competitiveness.

4.4.5.3 Benefits of a restriction on LQS with lead bullets

The Agency has been unable to quantify the benefits of a restriction on the use of bullets of any calibre in LQS. Table 10 summarises the benefits of a restriction on lead bullets in LQS. The Agency notes that whilst human health risks exist from this use, the SEA assumes all monetised human health benefits from restricting all uses

of lead ammunition in LQS to pertain to a shot restriction on the basis of a straightforward weighting of lead quantities used in shot versus bullets. The Agency estimates ~1,600t/a of lead shot to currently be used for LQS, compared to ~3t/a from bullets (not including airgun pellets). However, the Agency notes several uncertainties when considering the relative human health risks from lead shot versus lead bullets, as outlined in 4.1.2. During the SEA public consultation period the Agency will consider whether apportionment of this impact within the SEA is robustly feasible.

The ratio of lead emissions from LQS with shot versus bullets (excluding airgun pellets) is estimated to be 99.8:0.2. The impact of losing 1 IQ point on future earnings is unlikely to equal 0.002 times the impact of losing 0.002 IQ points. Indeed, a loss of 0.002 IQ points likely has no discernible effect, whatsoever. Such non-linearity leads the Agency to attribute 100% of human health impacts to a LQS shot restriction when using the straightforward per tonnage methodology. It is worth noting that the monetised human health benefits attributed to the LQS shot restriction may underestimate the true impact because they use the lower bound IQ loss estimates, lower bound IQ-earnings relationship, and lower bound CKD incidence.

Although benefits cannot be monetised, the cost-effectiveness ratio for a restriction on lead bullets for LQS are noticeably less favourable than for the shot restrictions, at an estimated £41,360/t for SC and £89,700/t for LC (see Section 2.6.1 for important methodological considerations when interpreting these figures). Additionally, no benefits in terms of avoided primary poisoning, avoided soil contamination, and avoided water contamination are anticipated as a result of restricting this use. As a result, the tonnage proxy is representing a smaller set of environmental risks. The Agency is unable to recommend a restriction on a SEA basis due to limitations in data meaning that a comparative scale of costs and benefits is not possible. Further assessments on proportionality and practicality will be undertaken during the consultation period.

Table 10 Summary of benefits: derogated restriction on lead bullets in LQS

Description of benefit	Type of benefits	PV benefit (20yrs)
Avoided bird deaths via secondary poisoning	Environmental	N/Q
Avoided sub-lethal effects in birds (suffering in poisoned birds who do not die from primary or	Environmental	N/Q

secondary exposure)		
Avoided risk to mammalian scavengers/companion animals.	Environmental	N/Q
Avoided neurodevelopmental impacts (proxied by avoided IQ loss)	Human Health	N/Q
Avoided increased incidence in CKD	Human health	N/Q
Avoided cardiovascular effects	Human health	N/Q

4.4.5.4 Benefits of a restriction plus derogation on TS with lead bullets

The Agency has been unable to quantify the benefits of a derogated restriction on this use. Benefits are the reduction in risk to ruminants/grazing animals, soil, and water, associated with a reduction in lead emissions to the environment of an estimated 100t across the 20-year time-period appraised (see section 2.8.1.5 of the Background Document for further information on the Agency's analysis). This derogated restriction also ensures that the 95% of emissions from this use that are currently recovered will continue to be recovered, even if the governing body for shooting should consider such health and safety RMMs to no longer be needed (not anticipated by the Agency). If recovery were not already in place at 95% of ranges, this derogated restriction would recover an estimated 2,010t across 20 years.

Although the Agency has been unable to monetise benefits, the estimated cost-effectiveness ratio of £5,500/t is similar to those of the recommended restrictions on lead shot: LQS, £5,700/t; TS, £5,300/t. However, a reduced set of environmental risks pertain to this use than that of the lead shot uses, so a comparison of cost-effectiveness ratios is an imperfect approach to comparing the relative costs of reducing risk. Additionally, several cost figures used in the cost-effectiveness ratio for this use are currently estimates by the Agency based on expertise rather than data.

Nonetheless, the Agency considers the benefits (both those monetised and non-monetised) of the recommended restrictions on lead shot to significantly outweigh the costs, and so considers their cost-effectiveness ratios to certainly justify intervention. As such, a caveated comparison to this based on other uses can provide a helpful benchmark in lieu of monetised benefits.

4.4.6 Proportionality

For an intervention to be proportionate it requires that its expected benefits to society outweigh the associated costs. Costs of restriction to the various uses have been monetised, with occasional need to supplement this quantitative analysis with qualitative information (particularly for the bullet uses). The Agency has been able to partially monetise the benefits of the proposals relating to lead shot, but a solely qualitative assessment has been necessary for the uses relating to lead bullets.

The Agency **draws the following conclusions on proportionality** based on its current analysis:

1) Restriction on live quarry shooting with lead shot

Even with a conservative approach to modelling the impacts of restriction and partial monetisation of benefits, the modelled benefits to society of a restriction outweigh the costs. As such, the Agency concludes that restriction on this use is a proportionate measure to address risk.

2) Restriction on target shooting with lead shot

Even with a conservative approach to modelling the impacts of restriction and partial monetisation of benefits, the modelled benefits to society of a restriction outweigh the costs. However, the Agency recommends a derogation on the use of lead shot for a select number of identified athletes noting this to likely be a more cost-effective intervention than a restriction for target shooting without a derogation. As such, the Agency's recommendation of a restriction with a derogation for athletes is concluded to be a proportionate measure.

3) Live quarry shooting with large calibre lead bullets ($\geq 6.5\text{mm}$)

The Agency has been unable to quantify the benefits of a restriction on the use of lead bullets. A quantitative risk assessment has not been conducted for this use, meaning the Agency is unable to compare quantitative, monetised or non-monetised impacts. Environmental and human health risks from this use exist that would be managed under restriction. If a formal benefit-cost ratio could be established, the Agency believes it would be less favourable than that of a restriction on lead shot. Indeed, the Agency's cost-effectiveness ratio is less favourable than that of the recommended lead shot restrictions. Additionally, no benefits in terms of avoided primary poisoning, avoided soil contamination, and avoided water contamination are anticipated as a result of restricting this use. As a result, the tonnage proxy is representing a smaller set of environmental risks. On a per tonnage basis, however, this use may pose a greater risk in terms of secondary poisoning than the uses of lead shot.

The Agency is unable to conclude whether restriction on this use is proportionate, but it is currently considered less proportionate than restriction (+ derogation) on the lead shot uses. Net benefits may be positive or negative;

although given the overall costs associated with this option are expected to be low, the level of benefit required to achieve proportionality would also be low.

Furthermore, the Agency still has concerns around the enforceability and practicality of this option – especially given that lead bullets will remain available for indoor and outdoor target shooting (see Section 2).

Hence, at this time, a restriction has not been recommended.

4) Live quarry shooting with small calibre lead bullets (<6.5mm)

As with large calibre lead bullets, the Agency has been unable to monetise the benefits of a restriction on the use of lead bullets. If a formal benefit-cost ratio could be established, the Agency believes it would be less favourable than that of both the recommended restrictions on lead shot, and also a large calibre lead bullet restriction. Because the benefits of restricting this use cannot be quantified, the Agency cannot conclude that restriction would be a proportionate intervention. However, the Agency considers that the net benefits of restricting this use would be smaller than that of the uses of lead shot and large calibre lead bullets for LQS, and could feasibly be negative. Further assessments on proportionality will be undertaken during the consultation period.

The Agency also has the same concerns around the enforceability and practicality of this option as with live quarry shooting with large calibre bullets (see Section 2). This will be investigated further during the consultation period.

Hence, at this time, a restriction has not been recommended.

5) Target shooting with large and small calibre lead bullets:

The Agency considers restriction with derogated use for all ranges with suitable risk management measures to be a proportionate intervention to address risk. Although the Agency has been unable to monetise benefits, the estimated cost-effectiveness ratio of £5,500/t is similar to those of the recommended restrictions on lead shot: LQS, £5,700; TS, £5,300. A reduced set of environmental risks pertain to this use than that of those lead shot uses, however, and so a comparison of cost-effectiveness ratios does not transparently reflect the costs of reducing the same risk. Additionally, several cost figures used in the cost-effectiveness ratio for this use are currently estimates by the Agency based on expertise rather than data. Nonetheless, the Agency considers the benefits (both those monetised and non-monetised) of the lead shot restrictions to significantly outweigh the costs, and so considers their cost-effectiveness ratios to certainly justify intervention. As such, a caveated comparison to this based on other uses can provide a helpful benchmark in lieu of monetised benefits. Additionally, a derogated restriction would also protect against future additional risk that would arise if the governing body's public safety requirements were to change. This is not reflected in the Agency's current tonnage proxy within the cost-effectiveness ratio.

The Agency considers that the proposed derogated restriction is proportionate, and as such recommends it.

6) Airguns (both uses)

The Agency has been unable to identify any monitorable or enforceable option to manage the risk from this use. As such, irrespective of how proportionate a restriction may be the Agency does not consider such intervention to currently be feasible.

4.4.7 Summary statistics

Table 11 below provides a variety of summary statistics arising from the Agency's analysis of the restriction options.

Table 11 Summary of costs and benefits for each use

Intervention	Reduced emissions (t lead, 20yrs)	Estimated present value costs (20 years)	Estimated present value benefits (20 years)	Benefit-cost ratio	Cost-effectiveness ratio (£/t* lead)	Notes
Restriction-LQS with lead shot	21,600	£112.9m	£206.4m	1.7	£5,700	Several environmental benefits have not been monetised and so are not included in this monetised comparison of impacts.
Restriction-TS with lead shot w/ derogation for athletes	79,800	£415.5m	£580.4m	1.4	£5,200	As above.
Restriction-LQS with LC lead bullets	21	£2.4m	N/Q	N/A	£89,700	Further information will be sought during the SEA PC period.

Intervention	Reduced emissions (t lead, 20yrs)	Estimated present value costs (20 years)	Estimated present value benefits (20 years)	Benefit-cost ratio	Cost-effectiveness ratio (£/t* lead)	Notes
Restriction-LQS with SC lead bullets	27	£1.1m	N/Q	N/A	£41,400	As above. Some costs not monetised.
Restriction-TS with lead bullets (all calibres) w/derogation for sites with suitable RMMs	100	£0.6m	N/Q	N/A	£5,500	Estimated emissions reduced reflects 5% of the total volume of lead relevant to this use, due to 95% recovery under the baseline. Further information will be sought during the SEA PC period.
Restriction-air weapon (both uses)	>13	N/Q	N/Q	N/A	N/A	

The Agency performed sensitivity analysis within its modelling of impacts, with more detail outlined in section 4.7.

4.5 Practicality and monitorability

Lead shot

Lead shot is already prohibited over wetlands in England, Wales and Scotland and a number of organisations are voluntarily moving away from lead shot for shooting live quarry. Other countries, for example Denmark, have already banned the use of lead shot for both live quarry and target shooting and ECHA has also proposed a restriction under EU REACH. This demonstrates that a restriction on the use of lead shot is practical to implement.

The experience in England, Wales and Scotland with a partial restriction of the use of lead shot over wetlands, but not other terrains, indicates that this poses difficulty with non-compliance and enforcement. A full restriction covering both placing on the market and use for both live quarry shooting and target shooting would facilitate enforcement as this can be done at the point of sale. It would be expected to result in a much higher level of compliance than a restriction on certain uses alone, with easier communication to the consumer. Lead shot is not used for indoor target shooting, so a prohibition on sale would not have adverse consequences for out of scope uses.

A derogation for a small number of individual athletes as identified by the appropriate sporting body to continue to be supplied is considered to be practical as these athletes are already identified by the relevant sporting bodies for the purposes of funding and training. The Agency is engaging further with relevant bodies in order to determine the most appropriate mechanism for continued supply.

One of the options being investigated is for some lead shot manufacturers/importers to supply the individual athletes directly (i.e., not via retailers) as this is considered to be the easiest way to monitor and enforce this derogation. Suppliers and athletes could be required to maintain records of the volumes of lead shot supplied/received and to provide this to the appropriate enforcement authority on request. Individual athletes granted permission to continue to use lead shot would not be able to share the lead shot with any other users. As these are professional athletes who would need to maintain their ability to participate in their sport the Agency considers that compliance with the terms of the derogation would be very high.

Lead bullets

The proposed restriction on lead bullets for target shooting with a derogation for those notified sites with appropriate risk management measures in place is considered practical. Information provided during the public consultation indicates that the majority of ranges already implement risk management measures to contain and recover bullets for reasons of health and safety following the NRA/NSRA guidance. It is also considered enforceable, although the process to determine this would need to be agreed which will require guidance about the type and level of evidence required.

Unlike with the use of lead shot where a restriction on the placing on the market is proposed for both target shooting and live quarry shooting, lead bullets will still be

available for lawful purchase for target shooting on sites that meet the criteria for derogation. This may create challenges regarding the enforceability of a restriction on lead bullets only for live quarry shooting. At this stage, the Agency is unable to determine whether lead bullets that remain available for target shooting would continue to be purchased for target shooting but used for live quarry shooting (unlawfully, in the event a restriction is proposed).

Additionally, there is a practical concern for such a restriction on live quarry shooting with lead bullets. It is expected that shooters pursuing live quarry will need to both 'zero' their rifles and practice, typically on shooting ranges, in order to ensure accuracy when shooting. Currently, non-lead bullets are not permitted to be used on a number of ranges primarily due to concerns around safety and unknown damage to infrastructure. This may make it difficult for shooters to practice or zero their rifles before engaging quarry, resulting in undesirable outcomes e.g., missed shots, wounding without killing.

The Agency is seeking to resolve these uncertainties in practicality and enforceability of any restriction which may be imposed (including differentiation between TS and LQS) during the consultation period.

4.6 Potential unintended consequences

The proposed restriction on lead shot, with a derogation for certain identified athletes, would limit the amount of lead entering the environment and eliminate the risk to human health from the ingestion of lead from game meat consumption. Likewise, ensuring that outdoor target shooting with bullets occurs only at sites able to demonstrate that they have considered risks to the environment and how to manage those risks through appropriate measures would lower the risk to the environment associated with this use.

However, the possible unintended consequences detailed below could occur as a result of the measures put in place to restrict the use of lead in ammunition.

Derogations have been proposed to allow identified athletes to train and compete without obstruction. However, others who aspire to reach that level could be hampered by the inability to train with lead shot which is required for use in international competitions. The Agency will continue to engage with the relevant sporting bodies which are responsible for the selection of the athletes, to help ensure that the correct balance between environmental protection and competitive British shooting is maintained.

It is expected that there will be occasions where GB host international competitions (such as the Olympics) whereby overseas competitors will be required to shoot lead. For these short and infrequent periods of time, the relevant sporting bodies are likely to temporarily specify more athletes under the derogation.

There is an increased potential for non-lead shot made from harder metals (and steel shot in particular) to ricochet from hard surfaces with an increased risk to shooters and bystanders. This will have implications for target shooting sports and also pest control in certain circumstances. For target shooting sports, shooting range design

will need to be considered to prevent ricochet from wayward shot rebounding from hard surfaces (e.g. trap houses); or in the case of Practical Shotgun disciplines where steel targets are fired at from ranges as little as 5 m, redesign of the targets / discipline to something that does not cause rebound. The increased potential risk from ricochet of harder non-lead shot may mean it may be unsuitable for pest control in and around farm buildings or stony or rocky ground and alternative methods of pest control may need to be considered such as traps or poisons.

Use of steel shot will typically require protective biodegradable plastic wads, as opposed to fibre wads; these will be present on the ground after firing for an unspecified period of time until they degrade and potentially will look unsightly, particularly if in large quantities associated with organised shoots. However, much will depend on the technical development and properties of the wads.

It could be a transition period does not give time to gain access to replacement shot before the use of lead shot is restricted. Those using shot will have to stop shooting instead of running the risk of buying lead ammunition which they will be unable to use within a certain time period, or else be out of pocket for this ammunition. It is expected that the transition will be widely publicised by trade associations and manufacturers so there will be awareness that this is coming. An additional “use-up” period after prohibition on the placing of the market may also help mitigate this latter issue. Nonetheless, alternatives are already available, and the transition period will give manufacturers the time to scale up production to increase this availability, meanwhile the EU restriction should also increase the availability of imports.

4.7 Assumptions, uncertainties and sensitivities

4.7.1 Uncertainties related to the risk assessment

Uncertainties in environmental assessment

The following uncertainties are identified, although the importance of each uncertainty is difficult to rank on a scientific basis:

- A number of estimates were provided for the tonnages of each ammunition type for each use, each with uncertainties depending on the estimation method used. In particular, estimates of airgun ammunition are very uncertain. Tonnage values selected for use in this assessment should not be seen as definitive but are sufficient for the purposes of this assessment for the reasons described in the Background Document.
- Although a risk has been identified for primary and secondary poisoning of birds, estimates of the numbers of birds at risk are uncertain (N.B., the number of organisms at risk has not been a factor in any environment-focussed restriction of other substances under REACH).
- No GB data on primary ingestion by grazing mammals have been identified, although it is assumed to be a possibility based on evidence

from other countries.

- No GB data on secondary poisoning of predatory or scavenging non-avian species have been identified
- GB data on lead concentrations in surface or groundwater associated with the use of lead ammunition are not available.
- A single study reports ingestion of airgun pellets by birds. It is unclear whether this exposure pathway is significant in GB.
- Throughout the dossier the risks posed have been considered for all uses of lead ammunition combined. Where the same risk is identified for different uses we have considered whether the relative risks can be determined qualitatively, but this assessment is uncertain. Tonnage used annually is used as a general indicator of relative risk. However, for secondary poisoning of birds in particular, the use of annual tonnage is not considered a suitable proxy to determine the relative partitioning of risks from lead derived from shot and lead derived from bullets.

Uncertainties in the human-health assessment

The following uncertainties in the human-health assessment are identified:

- Some estimates of the numbers of people in the UK that consume game birds were based on data that did not differentiate between wild-shot birds (potentially contaminated with lead) and farmed birds (not killed with lead ammunition).
- There is a lack of information on consumption of game meat by children and pregnant women.
- Large variations in lead concentrations in different game meat samples and cuts of meat, particularly for large game killed with bullets, because lead contamination from the ammunition is not evenly distributed throughout the animal; some samples might have highly elevated lead levels (for example, close to bullet wound channels), whereas in other samples levels might not be elevated.
- The relative contributions of game hunted with lead shot and game hunted with lead bullets to game meat consumption in GB, and the annual tonnage of the latter.
- The relative partitioning of human-health risks from lead derived from shot and lead derived from bullets, considering the impacts of released lead quantities, shot-to-kill ratios, lead distribution in the animals, proportion of hunted animals destined for human consumption, butchery practices and cuts of meat

consumed.

- Uncertainty about the proportion of ammunition-derived lead that is absorbed or how much BLLs are increased per unit of dietary lead ingested.
- Very limited information on how game meat consumption affects BLL in hunter families.
- A lack of reliable measurements of BLL in children of high game meat consuming (hunter) families.
- Impacts on human health of possibly different exposure patterns from the consumption of small game hunted with lead shot and large game hunted with lead bullets.

4.7.2 Sensitivities related to the socio-economic analysis

Many assumptions are made throughout the SEA. These are highlighted and discussed on an individual basis within the IA. Below is a non-exhaustive list of some key assumptions:

- 22% of shotguns are assumed to be unsuited to steel shot
- 50% of shooters who cannot use steel are assumed to switch to bismuth, 50% replace their shotgun with one suited to steel
- Several different assumptions taken within the monetisation of benefits
- The cost-effectiveness framework uses tonnage as a proxy for risk across different uses
- Relative ammunition prices are assumed to remain constant over time
- No shooters assumed to cease activity due to restriction.

There are various uncertainties around the impacts of restriction. To strengthen the Agency's analysis in light of these uncertainties, conservative assumptions have been used wherever possible, and a thorough sensitivity analysis has been conducted for the restriction proposals for lead shot. Sensitivity analysis has not been performed for the uses pertaining to lead bullets, partly due to the Agency not possessing meaningful data to base it on beyond arbitrary increases/decreases in the few variables that underpin the quantitative analysis, and because a semi-quantitative analysis of impacts has been undertaken. Because of this, such uncertainty can arguably be better explained qualitatively than through arbitrary changes of the few quantitative variables.

In the case of the restrictions on lead shot, the Agency’s recommendations are weighted much more on the results of quantitative analysis, within which there are a significant number of variables. Many of these variables have meaningful ranges which can be tested. As such, the Agency has been able to undertake an in-depth investigation of how such ranges affect the cost-benefit conclusions. However, during the consultation period the Agency will be considering whether sensitivity analysis on the bullet uses is a proportionate use of Agency resources.

Within the lead shot sensitivity analysis, three scenarios are considered: *optimistic*, *central*, and *pessimistic*. Optimistic refers to the case where the ratio of monetised benefits to costs is as high as may reasonably be assumed, and *pessimistic* vice versa -considered an absolute worst-case scenario by the Agency. All analysis of costs and benefits presented thus far has been that of the *central* case, but as the Agency has previously noted, many of the variables underpinning this central case are conservative. As such, the *central* estimate is still considered by the Agency to underestimate the benefits and overestimate the costs of restriction, **with the true impacts perhaps most likely to lie somewhere between the *central* and *optimistic* cases.**

Table 12 outlines the variables/assumptions tested in the shot restriction sensitivity analysis and their respective values, with and displaying resulting summary statistics.

Table 12 Summary of sensitivity analysis: shot restrictions

Assumption	Optimistic	Central	Pessimistic	Notes
Proportion of shotguns unable to use standard steel with or without basic modification	90%	22%	22%	No value less than 22% selected. The Agency considers 22%, if anything, to already be a pessimistic assumption. 90% selected in the optimistic case-this is an arbitrary assumption to test the impact of a proportion more akin to that of SEAC (95%). This significantly reduces the estimated costs of restriction.

Price of alternative shotgun ammunition relative to lead	Keep same as central case as this is already favourable	steel = £112/250, bismuth = £422/250, lead = £129/250	Steel inflates by 20% in 2024 from EU restriction, 30% in 2029 from GB restriction.	Arbitrary increase in the relative price of steel ammunition to account for uncertainty in the assumption that relative prices with stay the same as they currently are. This addresses any potential risk of supply concerns surrounding steel shot (which the Agency considers to already be addressed via the 5-year transition periods recommended.
BEIS carbon values + GHG scenario (£)	134	268	402	Values taken from the BEIS (2021) low, central, and high carbon values. These increase on an annual basis, see BEIS (2021) for more detail.
Proportion of individuals picking to buy new gun or switch to bismuth when unable to use steel shot.	100% bismuth	50:50 split	100% new gun purchase	Over a 20-year period, a 100% switch to bismuth results in lower societal costs than 100% purchase of new shotgun. True scenario will be somewhere between the optimistic and pessimistic, so this captures all possibilities.
Price of a new shotgun (£)	2,232	2,232	4,000	This is the LQS central price, different price used for TS (slightly cheaper). £4,000 value is arbitrary but aims to account

				for the possibility that the Agency's average shotgun price is too low.
Benefits transfer using mean in addition to median	Mean	Median	Median	Using the mean WTP more than doubles the estimated environmental benefits when compared to the median WTP.

Table 13 Present value costs and benefits under sensitivity analysis

Use	Optimistic PV costs	Central PV costs	Pessimistic PV costs	Optimistic PV benefits	Central PV benefits	Pessimistic PV benefits
LQS with lead shot restriction	£43.4m	£123.7m	£330.1m	£383.2m	£206.4m	£206.4m
TS with lead shot restriction w/ derogation	£156.3m	£415.5m	£1.11bn	£1.24bn	£580.4m	£580.4m
TS with lead shot restriction (no derogation)	£163.34m	£422.7m	£1.12bn	£1.25bn	£584.4	£584.4m

- Notes: figures in millions rounded to 1 d.p. Figures in billions round to 2 d.p. to allow for greater transparency in scale.

Table 14 Benefit-cost and cost-effectiveness ratios under sensitivity analysis

	BCR			CER		

Use	Optimistic BCR	Central BCR	Pessimistic BCR	Optimistic CER (£/t Pb)	Central CER (£/t Pb)	Pessimistic CER (£/t Pb)
LQS with lead shot restriction	8.8	1.7	0.6	£2,000	£5,700	£15,300
TS with lead shot derogated restriction	7.9	1.4	0.5	£1,900	£5,200	£13,900
TS with lead shot restriction	7.7	1.4	0.5	£2,000	£5,300	£20,000

As seen in , the Agency estimates the benefit-cost ratio of a restriction on LQS to range from 0.6-8.8, and a derogated restriction on TS to range from 0.5-7.9, depending on the assumptions made during modelling. The BCRs under the central case are 1.7 and 1.4 respectively, though this incorporates many conservative assumptions and a partial monetisation of benefits. As previously stated, **the Agency considers the true net impact to lie somewhere between the central and optimistic cases.**

The Agency acknowledges that under the pessimistic scenario the ratio of monetised benefits to costs is less than 1. The Agency considers this to be a worst-case scenario in terms of the costs of restriction, alongside a partial monetisation of benefits whereby the Agency has taken conservative steps in its approach. Even if this worst-case cost scenario were to arise (deemed unlikely by the Agency), the partial monetisation of benefits is considered to understate the scale of benefits relative to costs, such that the benefit cost ratio only reflects those benefits that have been monetised and hence will understate the true ratio.

5 References

- AEWA, 1999. African-Eurasian Migratory Waterbirds (AEWA) (1999). Resolution 1.14 Phasing out of lead shot in wetlands. First Meeting of the Parties to the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA). Cape Town, South Africa.
- BASC, 2020. Shooting and rural organisations take responsibility of move away from lead ammunition [WWW Document]. BASC. URL <https://basc.org.uk/shooting-and-rural-organisations-take-responsibility-of-move-away-from-lead-ammunition/> (accessed 12.13.21).
- BIR, 2008. Report on the Environmental Benefits of Recycling. Bureau of International Recycling (BIR).
- Bradbury, M.W., Deane, R., 1993. Permeability of the blood-brain barrier to lead. *Neurotoxicology* 14, 131–136.
- Butler, D.A., 2005. Incidence of lead shot ingestion in red-legged partridges (*Alectoris rufa*) in Great Britain. *Veterinary Record* 157, 661–662. <https://doi.org/10.1136/vr.157.21.661>
- Butler, D.A., Sage, R.B., Draycott, R.A.H., Carroll, J.P., Potts, D., 2005. Lead exposure in ring-necked pheasants on shooting estates in Great Britain. *Wildlife Society Bulletin* 33, 583–589. [https://doi.org/10.2193/0091-7648\(2005\)33\[583:LEIRPO\]2.0.CO;2](https://doi.org/10.2193/0091-7648(2005)33[583:LEIRPO]2.0.CO;2)
- Carson, R.T., Mitchell, R.C., Hanemann, M., Kopp, R.J., Presser, S., Ruud, P.A., 2003. Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill. *Environmental and Resource Economics* 25, 257–286. <https://doi.org/10.1023/A:1024486702104>
- COT, 2016. Addendum to the 2013 COT statement on potential risks from lead in the infant diet.
- CSR, 2020. Chemical Safety Report, Part B, Lead EC Number 231-100-4, CAS Number 7439-92-1, 27.
- Department for Energy Security and Net Zero, Department for Business, Energy and Industrial Strategy, 2021. Carbon valuation [WWW Document]. URL <https://www.gov.uk/government/collections/carbon-valuation--2> (accessed 5.1.23).
- Department of Health, Food Standards Agency, 2011. Diet and Nutrition Survey of Infants and Young Children, 2011. Department of Health.
- ECHA, 2022a. Annex XV restriction report - lead in outdoor shooting and fishing weights final background document. European Chemicals Agency, Helsinki, Finland.
- ECHA, 2022b. ECHA, Committee for Risk Assessment (RAC), Committee for Socio-economic Analysis (SEAC) Opinion on an Annex XV dossier proposing restrictions on Lead and its compounds.
- ECHA, 2021. Annex XV restriction report - lead in outdoor shooting and fishing weights. European Chemicals Agency, Helsinki, Finland.
- ECHA, 2020. Committee for Risk Assessment (RAC). Opinion on scientific evaluation of occupational exposure limits for lead and its compounds.
- ECHA, 2018a. Opinion: Proposing harmonised classification and labelling at EU level of Lead. (No. CLH-O-0000001412-86-260/F). Committee for Risk Assessment (RAC); European Chemicals Agency, Helsinki, Finland.
- ECHA, 2018b. Background document to the opinion on the Annex XV dossier proposing restrictions on lead compounds – PVC.

- ECHA, 2017a. Annex XV restriction report - lead in gunshot in wetlands. European Chemicals Agency, Helsinki, Finland.
- ECHA, 2017b. Annex to Annex XV restriction report - lead in gunshot in wetlands. European Chemicals Agency, Helsinki, Finland.
- ECHA, 2016. Guidance on information requirements and Chemical Safety Assessment Chapter R.16: Environmental exposure assessment.
- ECHA, 2014. Background document to the Opinion on the Annex XV dossier proposing restrictions on Lead and its compounds in articles intended for consumer use.
- ECHA, 2011. Background document to the opinions on the Annex XV dossier proposing restrictions on Lead and its compounds in jewellery.
- ECHA, 2008. Guidance on information requirements and chemical safety assessment Chapter R.10: Characterisation of dose [concentration]-response for environment.
- EFSA, 2010. Scientific Opinion on Lead in Food: EFSA Panel on Contaminants in the Food Chain (CONTAM). EFS2 8. <https://doi.org/10.2903/j.efsa.2010.1570>
- FSA, 2014. Measurement of the concentrations of metals and other elements from the 2014 UK total diet study [WWW Document]. URL <https://www.food.gov.uk/sites/default/files/media/document/measurement-of-the-concentrations-of-metals-and-other-elements-from-the-2014-uk-total-diet-study.pdf>
- FSA, 2002. Portion sizes and food groups [WWW Document].
- FSAS, 2012. Habits and behaviours of high-level consumers of lead-shot wild-game meat in Scotland. Project number FS421005 Habits and behaviours of high-level consumers of lead-shot wild-game meat in Scotland | Food Standards Scotland.
- Gerofke, A., Ulbig, E., Martin, A., Müller-Graf, C., Selhorst, T., Gremse, C., Spolders, M., Schafft, H., Heinemeyer, G., Greiner, M., Lahrssen-Wiederholt, M., Hensel, A., 2018. Lead content in wild game shot with lead or non-lead ammunition – Does “state of the art consumer health protection” require non-lead ammunition? PLoS ONE 13, e0200792. <https://doi.org/10.1371/journal.pone.0200792>
- Green, R., Taggart, M., Pain, D., Smithson, K., 2022. Implications for food safety of the size and location of fragments of lead shotgun pellets embedded in hunted carcasses of small game animals intended for human consumption. PLoS ONE 17, e0268089. <https://doi.org/10.1371/journal.pone.0268089>
- Green, R.E., Pain, D.J., 2015a. An evaluation of the risks to human health in the UK from lead derived from ammunition. Appendix 1, 93–148.
- Green, R.E., Pain, D.J., 2015b. Risks of health effects to humans in the UK from ammunition-derived lead, in: Delahay, R.J., Spray, C.J. (Eds.), Proceedings of the Oxford Lead Symposium. Lead Ammunition: Understanding and Minimising the Risks to Human and Environmental Health. Edward Grey Institute, University of Oxford, Oxford, pp. 27–43.
- Green, R.E., Pain, D.J., 2012. Potential health risks to adults and children in the UK from exposure to dietary lead in gamebirds shot with lead ammunition. Food and Chemical Toxicology 50, 4180–4190.
- Green, R.E., Taggart, M.A., Pain, D.J., Clark, N.A., Clewley, L., Cromie, R., Green, R.M.W., Guiu, M., Huntley, B., Huntley, J., Leslie, R., Porter, R., Roberts, J., Robinson, J.A., Robinson, R.A., Sheldon, R., Smith, K.W., Smith, L., Spencer, J., Stroud, D., 2023. Voluntary transition by hunters and game meat suppliers

- from lead to non-lead shotgun ammunition: changes in practice after three years. *Conserv Evid Jour* 20, 1–7.
<https://doi.org/10.52201/CEJ20/OQWU5273>
- HSE, 2022. Annex 15 Restriction Report: Proposal for a restriction of lead [WWW Document]. URL <https://www.hse.gov.uk/reach/registry-of-restriction-intentions.xlsx>
- Hurley, P., 2022. Shotgun Cartridge Manufacturing – Transition to Lead Free Production (No. 01.1). Blake International Ltd.
- JECFA, 2011. Joint FAO/WHO Expert Committee on Food Additives, Evaluation of certain food additives and contaminants: seventy-third report of the Joint FAO/WHO Expert Committee on Food Additives.
- Knott, J., Gilbert, J., Hoccom, D.G., Green, R.E., 2010. Implications for wildlife and humans of dietary exposure to lead from fragments of lead rifle bullets in deer shot in the UK. *Science of The Total Environment* 409, 95–99.
<https://doi.org/10.1016/j.scitotenv.2010.08.053>
- LAG, 2018. Update report from the Lead Ammunition Group. Lead Ammunition Group.
- LAG, 2015a. Lead ammunition, wildlife and human health: a report prepared for the Department for Environment, Food and Rural Affairs and the Food Standards Agency in the United Kingdom. Lead Ammunition Group.
- LAG, 2015b. Appendices to Lead Ammunition Group report.
- Martin, A., Müller-Graf, C., Selhorst, T., Gerofke, A., Ulbig, E., Gremse, C., Greiner, M., Lahrssen-Wiederholt, M., Hensel, A., 2019. Comparison of lead levels in edible parts of red deer hunted with lead or non-lead ammunition. *Science of The Total Environment* 653, 315–326.
<https://doi.org/10.1016/j.scitotenv.2018.10.393>
- Mateo, R., Baos, A.R., Vidal, D., Camarero, P.R., Martinez-Haro, M., Taggart, M.A., 2011. Bioaccessibility of Pb from Ammunition in Game Meat Is Affected by Cooking Treatment. *PLoS ONE* 6, e15892.
<https://doi.org/10.1371/journal.pone.0015892>
- Mateo, R., Cruz, R., M., V.I.D.A.L., D., R.E.G.L.E.R.O., M., Camarero, P., 2007. Transfer of lead from shot pellets to game meat during cooking. *Science of the Total Environment* 372, 480–485.
- Meyer, C.B., Meyer, J.S., Francisco, A.B., Holder, J., Verdonck, F., 2016. Can Ingestion of Lead Shot and Poisons Change Population Trends of Three European Birds: Grey Partridge, Common Buzzard, and Red Kite? *PLoS ONE* 11, e0147189. <https://doi.org/10.1371/journal.pone.0147189>
- Meyer, C.B., Walker, T.A., Francisco, A.B., Morrison, E.B., Meyer, J.S., 2022. Method to assess the potential magnitude of terrestrial European avian population reductions from ingestion of lead ammunition. *PLoS ONE* 17, e0273572. <https://doi.org/10.1371/journal.pone.0273572>
- Molenaar, F.M., Jaffe, J.E., Carter, I., Barnett, E.A., Shore, R.F., Marcus Rowcliffe, J., Sainsbury, A.W., 2017. Poisoning of reintroduced red kites (*Milvus Milvus*) in England. *Eur J Wildl Res* 63, 94. <https://doi.org/10.1007/s10344-017-1152-z>
- NRA, 2022. Range Design and Safety Handbook. National Rifle Association. <https://nra.org.uk/wp-content/uploads/NRA-RANGE-DESIGN-AND-SAFETY-HANDBOOK-DEC-2022-22-12-22-1.pdf>

- PACEC, 2006. The Value of Shooting The economic, environmental, and social benefits of shooting sports in the UK. PACEC.
- Pain, D.J., Carter, I., Sainsbury, A.W., Shore, R.F., Eden, P., Taggart, M.A., Konstantinos, S., Walker, L.A., Meharg, A.A., Raab, A., 2007. Lead contamination and associated disease in captive and reintroduced red kites *Milvus* in England. *Science of The Total Environment* 376, 116–127. <https://doi.org/10.1016/j.scitotenv.2007.01.062>
- Pain, D.J., Cromie, R.L., Newth, J., Brown, M.J., Crutcher, E., Hardman, P., Hurst, L., Mateo, R., Meharg, A.A., Moran, A.C., Raab, A., Taggart, M.A., Green, R.E., 2010. Potential Hazard to Human Health from Exposure to Fragments of Lead Bullets and Shot in the Tissues of Game Animals. *PLoS ONE* 5, e10315. <https://doi.org/10.1371/journal.pone.0010315>
- Pain, D.J., Dickie, I., Green, R.E., Kanstrup, N., Cromie, R., 2019. Wildlife, human and environmental costs of using lead ammunition: An economic review and analysis. *Ambio* 48, 969–988. <https://doi.org/10.1007/s13280-019-01157-2>
- PHE, 2017. Compendium of Chemical hazards: lead.
- Schulz, J.H., Wilhelm Stanis, S.A., Morgan, M., Li, C.J., Hall, D.M., Webb, E.B., 2021. Perspectives from natural resource professionals: Attitudes on lead ammunition risks and use of nonlead ammunition. *Journal of Outdoor Recreation and Tourism* 33, 100341. <https://doi.org/10.1016/j.jort.2020.100341>
- Stanbury, A., Eaton, M., Aebischer, N., Balmer, D., Brown, A., Douse, A., Lindley, P., McCulloch, N., Noble, D., Win, I., 2021. The status of our bird populations: the fifth Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man and second IUCN Red List assessment of extinction risk for Great Britain. *British Birds* 114, 723–747.
- Taggart, M.A., Shore, R.F., Pain, D.J., Peniche, G., Martinez-Haro, M., Mateo, R., Homann, J., Raab, A., Feldmann, J., Lawlor, A.J., Potter, E.D., Walker, L.A., Braidwood, D.W., French, A.S., Parry-Jones, J., Swift, J.A., Green, R.E., 2020. Concentration and origin of lead (Pb) in liver and bone of Eurasian buzzards (*Buteo buteo*) in the United Kingdom. *Environmental Pollution* 267, 115629. <https://doi.org/10.1016/j.envpol.2020.115629>
- Taylor, C.M., Golding, J., Emond, A.M., 2014. Intake of game birds in the UK: assessment of the contribution to the dietary intake of lead by women of childbearing age and children. *Public Health Nutrition* 17, 1125–1129.
- Walker, L.A., Lawlor, A.J., Potter, E.D., Pereira, M.G., Sainsbury, A.W., Shore, R.F., 2012. Lead (Pb) concentrations in predatory bird livers 2010: a Predatory Bird Monitoring Scheme (PBMS) report (pp. 13): Centre for Ecology and Hydrology (CEH), Lancaster, UK.
- Wild Justice, 2023. Pheasant breasts sold in Lidl contaminated with lead levels up to 85 x higher than legal limit set for non-game meat [WWW Document]. Wild Justice. URL <https://wildjustice.org.uk/lead-ammunition/pheasant-breasts-sold-by-lidl-contaminated-with-lead-levels-up-to-85-x-higher-than-legal-limit-set-for-non->
- WWF [WWW Document], 2023. . WWF Footprint Calculator. URL <https://footprint.wwf.org.uk/>

Further information

This document is available at: www.hse.gov.uk/pubns/indg000.htm.

© *Crown copyright* If you wish to reuse this information visit [www.hse.gov.uk/copyright](http://www.hse.gov.uk/copyright.htm).htm for details. First published 10/23.

Published by the Health and Safety Executive 10/23

Annex 1: List of acronyms

- ALARA** – As Low as Reasonably Achievable
- ALARP** – As Low as Reasonably Practicable
- BASC** – British Association for Shooting and Conservation
- BLL** - Blood lead levels
- BMDL** – Lower confidence limit of the benchmark dose
- BMR** – Benchmark response
- BSSC** – British Shooting Sports Council
- CI** – Confidence interval
- CKD** – Chronic kidney disease
- CLP** – Classification, Labelling and Packaging
- CMR** – Carcinogen/Mutagen/Reproductive Toxicant
- COI** – Cost of Illness
- COT** – Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment
- CPSA** – Clay Pigeon Shooting Association
- DMEL** – Derived Minimal Effect Level
- DNEL** – Derived No Effect Level
- DNSIYC** – Diet and Nutrition Survey of Infants and Young Children
- ECHA** – European Chemicals Agency
- EFSA** – European Food Standards Authority
- EQS** – Environmental quality standard
- EU** – European Union
- EUML** – European Union maximum level
- EU MRL** European Union Maximum Residue Level
- FSA** – Food Standards Agency
- FSAS** – Food Standards Agency in Scotland
- GB** – Great Britain
- GBP** – Great British Pound (*Pound Sterling*)
- GTA** – Gun Trade Association
- HSE** – Health and Safety Executive
- HSENI** – Health and Safety Executive Northern Ireland
- ILGRA** – Interdepartmental Liaison Group on Risk Assessment

IQ – Intelligence quotient

IOC – International Olympic Committee

IUPAC – International Union of Pure and Applied Chemistry

JRC – Joint Research Centre

MCL – Mandatory Classification and Labelling

MOE – Margin(s) of exposure

NDNS – National Diet and Nutrition Survey

NHS – National Health Service

OPSS – Office for Product Safety and Standards

PNEC – Predicted no-effect concentration

PV – Present Value

RAC – Risk Assessment Committee

RCR – Risk Characterisation Ratio

REACH – Registration, Evaluation, Authorisation and Restriction of Chemicals

RISEP – REACH Independent Scientific Expert Pool

RO – Restriction Option

RPC – Regulatory Policy Committee

SCCP – Scientific Committee on Consumer Products (*now Scientific Committee on Consumer Safety, SCCS*)

SEA – Socio-Economic Analysis

SEAC – Socio-Economic Assessment Committee

STOT RE – Specific Target Organ Toxicity- Repeat Exposure

STOT SE – Specific Target Organ Toxicity – Single Exposure

U.V. – Ultra-Violet

U.S. – United States

WTP – Willingness To Pay

Annex II: List of definitions

This opinion document covers the use of lead projectiles as used in shotguns, firearms and airguns, all of which are as defined in the Firearms Act 1968.

The definitions of some of the common terms in this document are given below.

Accuracy	The ability of a weapon system to place the Mean Point of Impact (MPI) of a series of bullets / projectiles on a given aiming point.
Action	The mechanism by which a shot gun or rifle is loaded or unloaded, examples include: break-action, where the barrels are hinged in front of the trigger/ firing mechanism to expose the breech and allow loading and unloading of cartridges; and bolt-action, where a rotating bolt (comprising a metal breech-block incorporating the firing pin and extractor, and handle) is manipulated to expose the breech to allow loading and unloading.
[Gun] Barrel	A barrel is the metal tube that the projectile travels through as a result of pressure from burning gunpowder, compressed air, or other like means. The barrel also guides the projectile in the intended direction.
Backstop	A barrier behind the target capable of stopping a projectile / shot. It may be formal as in a stop-butt, or informal such as the ground, or a sufficient area of land that there is no risk of hitting an unintended target.
Bore or gauge	Bore relates to a unit of measurement used to express the inner diameter (bore diameter) of the barrel and is equivalent to the number of solid spheres of lead that will fit the bore of the firearm required to make up one pound of lead, i.e., 12-bore is equivalent to 12 x 1/12 lb lead spheres. Bore is the more common GB terminology.
Breech	The rear end of the barrel and position of loading in the case of breech-loading firearms, as opposed to muzzle-loaders which are loaded from the front (muzzle) end of the barrel.
Bullet / round	A projectile and component of ammunition fired from a gun.
Calibre	Is the measurement of the interior (the bore) of a gun's barrel and the diameter of bullet ammunition used expressed in inches or millimetres.

Cartridge	A precision made container (typically metal or plastic) comprising projectile(s), propellant and primer, designed to fit into the chamber of a breech loading firearm.
Centrefire	A metallic cartridge cased bullet, where the primer is a metal cup containing the primer compound inserted into the centre of the base of the cartridge, which on firing ignites the main propellant charge.
Chamber	The cavity at the rear of a breech loader's barrel into which the cartridge is inserted; the rear opening of the chamber is the breach.
Choke	A minute tapered constriction of the last few inches of the muzzle end of a gun barrel; typically found in shotguns, but also on some rifles, pistols and airguns. The constriction serves to shape the pattern of the shot to improve shot density, range and accuracy. Chokes may be 'fixed' or screw-in.
Choking	Referring to the amount / thickness of barrel choke in place. For example, full-choke (0.040 inches) or half-choke (0.02 inches).
Clay pigeon shooting	The use of a shot gun to shoot at targets fired into the air to imitate shooting at live quarry.
Consistency	The degree of dispersion of a series of bullets / projectiles about the Mean Point of Impact.
De-leading	The removal of lead from sand or granulated rubber bullet catchers, where it has built up over time and may begin to pose a safety hazard.
Firearm	The Firearms Act 1968 Section 57(1B) uses the definition of a firearm as a "lethal barrelled weapon" as a "barrelled weapon of any description from which a shot, bullet or other missile, with kinetic energy of more than one joule as measured at the muzzle of the weapon, can be discharged". As such it can mean shotguns, rifles, pistols, airguns etc.
Full bore target rifle	A rifle firearm with a larger diameter bore, generally chambered for 7.62 x 51 mm NATO or .308 inch Win centrefire cartridges.

Group / grouping	The collective pattern of impacts on a target from successive shots in a single shooting session from rifles, pistols or airguns, for example firing five bullets at the same target. The tightness of the group (i.e., how close together the impacts are to each other on the target) is an indication of the precision of the weapon and the skill of the shooter. The distance from the centre of the group to the intended point of aim (usually the centre of the target) is a measure of accuracy.
Indoor	Inside a building
Large Game, large	Quarry species that are relatively large. For example: deer, wild boar, etc.
Live quarry shooting	The use of a weapon to shoot at a living target. In the UKGB, this term is more commonly used than 'hunting'.
Muzzle loader	Any firearm which is loaded from the muzzle end.
Outdoor	All uses that do not occur inside a building.
Pellet	Small spherical or 'tube' shaped projectile. Typically comprising shot or airgun ammunition.
Precision	The ability to place a bullet / projectile on the point of aim.
Primer	A chemical compound that ignites the propellant (e.g., gunpowder) when struck by a firing pin. Primer may be placed either in the rim of the case (rimfire) or in the centre of the base of the case (centrefire).

Projectile(s)	Object(s) expelled from the barrel of a gun. Examples of relevant types of projectiles are bullets, gunshot, shotgun 'slugs', air gun pellets and BBs.
Raptors (predatory or scavenging)	Predatory birds (birds of prey) that have keen vision, powerful talons with claws and strong curved beaks, including owls. These birds can also scavenge carrion, either occasionally or as their main food source.
Rifle	Firearm incorporating a barrel marked with spiralling grooves causing the bullet to spin to improve the bullet's range and accuracy.
Rimfire	A metallic cartridge cased bullet, where the primer is located within a circumferential rim protruding from the base of the cartridge case. When firing, the firing pin will strike the rim (hence rimfire), sparking the primer compound within the rim, and igniting the main propellant charge
Scavenging birds (non-raptor)	Other bird species that typically scavenge carrion, e.g., vultures, corvids, gulls.
Shot	A mass of small spherical projectiles. In breech-loading shotguns these are usually contained in a cartridge. For muzzle-loading shotguns the shot is poured loose into the barrel from the muzzle end.
Side-by-side	A double-barrelled shotgun where both barrels are placed horizontally beside each other, as opposed to 'over-and-under' where the barrels are placed one above the other.
Small game, small	Quarry species that are relatively small. For example: ducks, pheasants, partridges, hares, squirrels, rabbits, foxes, etc.
Smallbore target rifle	A rifle firearm with a narrow bore, generally .22 inch calibre (5.6 mm bore) rimfire chambered for cartridges such as the .22 Short, .22 Long, or .22 Long Rifle cartridges.
Stop butt	Engineered bank, berm, wall or other device, behind and around the target on a shooting range, intended to stop all misdirected shots that may reasonably be expected to be fired.

Target shooting	The use of a weapon to shoot at an inanimate (non-living) target. Includes practice, or other shooting, performed in preparation for 'hunting'. Examples of relevant types of targets are 'clay pigeons', paper targets, biathlon targets, silhouettes, etc.
Waterbird	Used in the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) to refer to birds that are ecologically dependent on wetlands for at least part of their annual cycle. This definition includes many species of divers, grebes, pelicans, cormorants, herons, storks, rails, ibises, spoonbills, flamingos, ducks, swans, geese, cranes, waders, gulls, terns and auks.
Waterfowl	Typically, species from the avian family Anatidae, i.e., ducks, geese and swans. These birds are adapted for surface water swimming (i.e., having webbed feet and oily feathers). However, a broader interpretation to include other waterbirds (e.g., Common Snipe) that are hunted is not uncommon. Hunted waterfowl and waterbirds can be referred to as <u>game waterfowl</u> .
Welfare	The physical and mental state of an animal in relation to its environment. Welfare can be considered in terms of whether an animal is suitably fed and housed, in good health and exhibiting normal behaviours.
Wildfowl	Principally associated with the hunting of waterfowl, although can refer to any hunted (game) bird, such as waders, grouse, pheasants, or partridges.
Wildfowling	The hunting of wildfowl, particularly ducks, geese and waders.