Nuclear Decommissioning Authority

Eden Nuclear and Environment

NDA Strategy (2021)

Integrated Impact Assessment Report

Non Technical Summary

Final

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Contents

1.0 Introduction

1.1 The NDA Mission

The Nuclear Decommissioning Authority (NDA) is a non-departmental public body established under the Energy Act 2004. The NDA's mission is to deliver safe, sustainable and publicly acceptable solutions to the challenge of nuclear clean-up and waste management.

1.1.1 The UK's Nuclear Legacy

The NDA has responsibility for overseeing the clean-up and decommissioning of 17 of the UK's civil, public-sector nuclear sites (see Figure 2-A and Subsection 1.2). These range from Sellafield, a complex decommissioning site, to previously operational nuclear power stations and nuclear research facilities.

Decommissioning old nuclear facilities produces radioactive waste. This is material that has no further use and is above a certain (very low) level of radioactivity. It is also produced by operational nuclear facilities. Over the years the UK has accumulated a substantial legacy of radioactive waste from various civil nuclear and defence programmes. Radioactive waste also arises in non-nuclear industries, for example where radioactive materials are used for medical and industrial purposes.

In the UK, radioactive wastes are classified according to the type and quantity of radioactivity they contain and how much heat this radioactivity produces [1]. There are four main categories of radioactive waste:

- High Level Waste (HLW) – waste that is sufficiently radioactive for the energy released as it decays to significantly increase its temperature and the temperature of its surroundings. This heat generation has to be taken into account in the design of storage and disposal facilities.
- Intermediate Level Waste (ILW) – waste with more than 4 gigabecquerel (GBq)[1] per tonne of alpha activity[2] or 12 GBq per tonne of beta/gamma activity, but that does not produce significant heat.
- Low Level Waste (LLW) – contains relatively low levels of radioactivity, not exceeding 4 gigabecquerel (GBq) per tonne of alpha activity, or 12 GBq per tonne of beta/gamma activity.
- Very Low Level Waste (VLLW) - a sub-category of LLW with specific activity limits.

These categories are generally grouped into Higher Activity Waste (HAW), which includes HLW, ILW and some LLW, and Lower Activity Waste (LAW), which includes the majority of LLW and all VLLW.

The NDA develops nuclear decommissioning plans and implements them through an estate-wide Strategy. This Strategy sets the pace and priority of decommissioning activities across the estate, and ensures the safe management of spent fuels, nuclear materials and radioactive wastes. The Strategy is based on a process of identifying and selecting preferred options which balance safety, cost and security with achieving benefits for the environment and society.

1.2 The NDA Estate

The NDA estate includes reactors, chemical plants, research and development facilities, fuel fabrication and reprocessing facilities, waste treatment facilities and waste stores. Some plants date from the 1940s and 1950s, including a number of the legacy ponds and silos at Sellafield. These facilities are ageing and contain significant quantities of spent fuel, presenting some of the highest risks in the estate and representing some of the NDA's greatest decommissioning challenges.

[1] A gigabecquerel is a unit of radioactivity. It is equivalent to one billion radioactive atoms decaying every second.
[2] Alpha, beta and gamma radiation are different types of radiation. They are caused by different physical processes and have different properties.

A few facilities across the estate continue to form an essential part of the nation's nuclear infrastructure, which means they must continue to be operated safely and effectively until they have fulfilled their purpose.

1.3 NDA Strategy (2021)

Under the Energy Act 2004, the NDA is required to publish a Strategy setting out its strategic direction for activities across its estate. This Strategy is subject to periodic review, formal public consultation and approval by ministers. The first Strategy was published in 2006, with subsequent updates published in 2011 and 2016.

The Nuclear Decommissioning Authority (NDA) is undertaking its third five-year review of its Strategy, in accordance with the Energy Act 2004. The Strategy reviews the NDA's strategic position, establishing and maintaining its strategic direction over activities across its sites. The strategies that have been selected are carried out by site licence companies (SLCs), which manage the sites on the NDA's behalf and under its strategic guidance.

The version currently under development is the NDA Strategy (2021) (otherwise referred to as the 'Strategy'). The NDA is committed to ensuring that the development of its Strategy is in accordance with the requirements of the European Union's Strategic Environmental Assessment (SEA) Directive and transposing UK SEA Regulations.

The SEA includes environmental considerations, and some health and socio-economic considerations. The NDA also wishes to adhere to good practice by conducting a Health Impact Assessment (HIA) and a Socio-economic Impact Assessment (SeIA). The NDA has incorporated the SEA, HIA and SeIA in an Integrated Impact Assessment (IIA), which includes more detailed assessments of health and socio-economic effects, as well as the statutory requirements of the SEA. Therefore, in the context of this report, the term SEA refers only to the environmental assessments. The health and socio-economic consideration that form part of the legally required SEA are covered under the HIA and SeIA.

IIAs are used by planners and policy makers to inform options, policies and strategies. They draw together different types of assessment to provide a broad and holistic perspective which can be easily communicated to stakeholders.

This document is the Non-Technical Summary of the IIA that accompanies the NDA Strategy (2021) document. It provides an overview of the Strategy's potential environmental, socio-economic and health effects. The full IIA Report is split into three volumes:

- **Volume 1:** consists of an introduction, the project background, descriptions of preferred and credible options, the approach to assessment and methodology, results of the assessment, the measures identified to mitigate risks and enhance opportunities, and conclusions and next steps.
- **Volume 2:** provides the detailed assessment of preferred options and reasonable alternatives.
- **Volume 3:** consists of a baseline report and review of relevant policy and legislation.

For further information on the IIA please refer to the main report. Where appropriate, references to the main report are provided throughout this document.

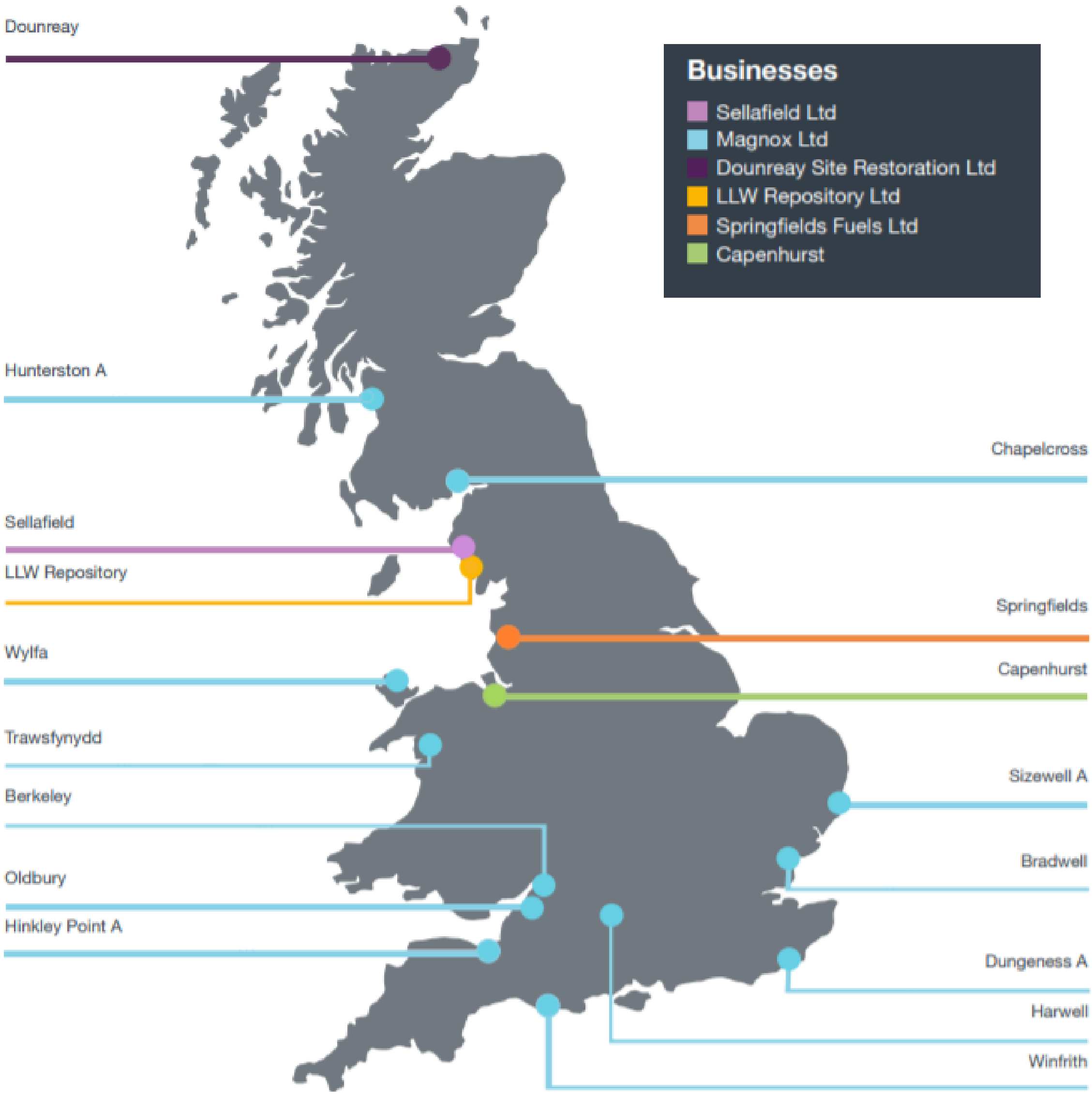

Figure 1-A: The NDA Estate [2]

2.0 Baseline Conditions

2.1 Introduction

To inform the assessment, information was collected on the baseline environmental, health and socio-economic conditions at each of the NDA sites. This information covers both existing conditions and future conditions that would be likely to evolve assuming there are no further changes to the NDA Strategy. The results of this exercise are presented in Volume 3 of the IIA Report, which includes a description of the 17 sites comprising the NDA estate.

Understanding the baseline at each of the NDA sites is important, both for determining the nature and extent of potential impacts of the Strategy and for identifying options which may improve environmental, social and health conditions.

The key issues highlighted by the baseline data gathering exercise are outlined below.

2.2 Environment

From an environmental perspective, some of the main issues at the sites are associated with the use of materials and resources and the generation, storage and treatment of wastes. Substantial volumes of waste (radioactive and, especially, non-radioactive) are produced as sites undergo decommissioning. Following retrieval, the higher-activity radioactive waste (HAW) is stored in purpose-built facilities pending treatment or disposal. The non-radioactive waste and LLW are treated for reuse or recycled where possible or, as a last resort, transported to authorised disposal sites. Waste management creates a range of additional environmental issues around air quality, noise, landscape, radiological discharges, energy use and carbon emissions.[3]

Due to their industrial nature, many of the NDA sites are prominent features in their landscapes and are widely visible across surrounding areas.

Most of the sites are in coastal locations, which could put them at risk from changes in the coastal environment. This may include increased rates of erosion, changes in tidal surges or sea level rise. Such changes are likely to be caused or accelerated by climate change.

Many of the sites have areas of chemical and radiological land contamination which may require remediation as part of decommissioning. The nature, extent and severity of such contamination varies from site to site, and across different parts of a site. Management of such contamination is an important element in moving sites towards their site end state.

Across the sites, there is ongoing management of radiological discharges and wastes. At a number of sites, radiological discharges continue within authorised limits, while others have seen discharges reduce or cease since the end of the operational phase. Decommissioning can cause short-term increases in discharges of radioactivity, before reducing overall radiological risks.

During the course of nuclear operations, many of the NDA sites have drawn water from and make discharges to water bodies. Some sites continue to do this. Such abstractions and discharges have been made within regulatory limits and, in most cases, have decreased since the operational phase ended. The Sellafield site continues to abstract water to support ongoing operations. Decommissioning activities undertaken at other sites may also continue to affect the water environment through abstraction and discharges.

Energy use and carbon emissions are important issues at NDA sites. Decommissioning activities such as demolition and operational activities such as reprocessing at Sellafield require energy and generate direct and indirect carbon emissions.

[3] 'Carbon emissions' is a conventional term used in place of greenhouse gas emissions, which are typically measured using units of 'carbon equivalents' (CO_2e). As such, the term 'carbon emissions' refers to all greenhouse gas emissions for the purposes of this assessment.

2.3 Socioeconomics

Due to their remote locations, many NDA sites are major employers in the surrounding area., Due to the varying nature of nuclear operations ongoing at each of the sites, the jobs supported range from construction and demolition work to specialist nuclear, civil engineering and managerial positions.

Similarly, some of the sites have been and continue to be major sources of investment into their local and regional economies. This investment comes not just from employment but also from multiplier effects and activities in the sites' supply chains.

At one time or another, each of the sites in the NDA's estate has been considered a national asset, supplying electricity derived from nuclear power or advancing the nation's nuclear capabilities through experimental research. Some sites contain facilities that continue to serve as national assets and must be maintained as such until they have fulfilled their purpose. Sellafield is one such site, although it is rapidly approaching a focus solely on decommissioning. Others continue to undergo decommissioning and may eventually be divested for redevelopment to become local assets. An example of this is the transfer of some of the research facilities at Berkeley Centre (owned by the NDA and adjacent to the Berkeley reactor decommissioning site) to South Gloucestershire and Stroud College, with a view to providing training in the renewable energy and nuclear sectors.

The demand for nuclear skills comprises existing generation, decommissioning, civil new build, defence and research and development [3]. Uncertainty in the number and nature of new build facilities creates ambiguity in predicting future workforce demand profiles. There is potential for the pool of available qualified nuclear staff to be in increased demand between now and 2030 [3], which could potentially impact the NDA mission at any time. As a result of an aging workforce and potential increase in demand from new build, a net inflow of staff is required into the industry, along with redeployment of skilled workers [3]. However, the number of staff anticipated to be required at NDA sites is expected to reduce, with some decommissioning sites anticipated to have no staff within the next 10 years [4].

2.4 Health

Across the sites, radiological health risks are an important consideration. Whether demolishing an office block or management of HLW arising from spent fuel reprocessing, radiological safety remains a key priority. This will continue to be the case until the sites have reached their end states, at which point the residual risks presented by radioactive substances remaining on-site (if any) are, and will continue to be, consistent with regulatory risk and dose guidance levels, without the need for controls. The use of safety cases, minimisation of waste, adherence to 'as low as reasonably achievable' (ALARA) principles and requirements to demonstrate the use of 'best available techniques' (BAT) help to ensure risks to workers, the public and the environment are minimised and kept well within statutory limits.

However, the main health risks arising from activity at NDA sites come from conventional sources, such as construction, demolition and transport. The environmental impacts of construction works can affect health. Changes in air quality can lead to increased risk of cardiovascular and respiratory illness. Increases in noise levels and alterations to the landscape can lead to disturbance and annoyance, while changes in water quality may result in adverse health effects if the water is used for drinking or recreation. Increases in traffic due to the movement of materials, plant and workers has the potential to increase the risk of road accidents on routes leading to and from the sites.

Such environmental effects can also affect the attractiveness of local recreational and amenity features, which might lead to declines in levels of physical activity undertaken by the local population.

Mental health and well-being is another important health issue relating to activities across the NDA estate. Increased stress and anxiety can be experienced by those living close to industrial sites which generate noise, dust and other environmental effects. On the other hand, by providing and maintaining employment opportunities and encouraging investment into the local community, sites can positively influence the mental health and well-being of the local population.

3.0 The Strategy

3.1 Themes, Topics and Credible Options

As set out in the Strategy, there are four driving strategic themes under which the NDA groups its core activities:

- Site Decommissioning and Remediation
- Spent Fuels
- Nuclear Materials
- Integrated Waste Management

These four driving themes are supported by a fifth theme: 'Critical Enablers'. This theme covers other aspects of the NDA's activities (such as transport and logistics, public and stakeholder engagement and land and property management) which support the overall delivery of the NDA mission. For the purpose of the assessment, Critical Enablers have been considered, where relevant, under each of the four driving themes.

Within each driving strategic theme, activities may be further broken down into topic strategies. For example, the Spent Fuels strategy is split into three individual topics: Spent Magnox Fuel, Spent Oxide Fuel and Spent Exotic Fuel. These topic strategies form part of the overarching Strategy.

For each strategic theme and topic, a number of credible options have been identified and defined. These options, which are described in papers produced by the NDA and published on its website, are the focus of this IIA.

Note that the intention of the IIA Report is to provide an indicative assessment of current credible options but not to preclude the adoption of other management options in the future. This recognises the fact that some options not currently considered to be credible or preferred because of their level of technical development may become more credible in the future as technology matures. Changes in government policy and site-specific considerations can also influence the credibility of strategic options over time.

3.2 Site Decommissioning and Remediation

The Site Decommissioning and Remediation theme outlines the NDA's approach to decommissioning redundant facilities, securing the land required for decommissioning activities and the means by which contamination of ground and groundwater will be managed. Such decisions are made on a case-by-case basis.

This strategic theme is divided into four topics:

3.2.1 Decommissioning

There are three broad credible options for Decommissioning:

1. **Decommissioning at a pace**
2. **Decommissioning slowly but without interruption**
3. **Deferred decommissioning,** which involves one or more periods when the facility is purposely made safe for a period of quiescence, during which only routine maintenance activities would be carried out

3.2.2 Land Quality Management

Land Quality Management involves managing risks to people and the environment from radioactive and non-radioactive contamination in ground and groundwater. This is done through prevention and remediation (including control and monitoring).

Four credible options have been identified for Land Quality Management. These are:

1. ***In situ*: management without intervention** (e.g. monitored natural attenuation or monitored natural decay)
2. ***In situ*: management with intervention** (e.g. enhanced bioremediation or physical treatment)
3. ***Ex situ*: management for reuse** (this may involve a process such as soil washing to make material suitable for reuse)
4. ***Ex situ*: excavation for disposal** (this option involves removing the material from the ground and transferring it to an authorised waste disposal site)

3.2.3 Site End States

Every NDA site will have an agreed site end state. The site end state sets out the long-term restoration objectives for the site, considering the land's next planned use or probable future uses. For many NDA sites, the end state is not scheduled to be achieved for many decades, so it is important to ensure there is flexibility in the long-term site remediation plans. Over time, the description of the end state becomes more detailed as decommissioning progresses and a clearer picture of the site's characteristics emerges.

A wide range of issues could affect a site's proposed site end state, such as changes in policy and regulations, advances in technology and changes in the desires of a community. It may not be realistic or necessary to remediate a site completely (i.e. removing all hazards so that the site may be suitable for any use). For some sites, remediation will focus on preparing the site for a specified beneficial use.

There are three credible options for the Site End States strategy:

1. **Leave the hazard where it is and prevent use**
2. **Make land suitable for next planned use**
3. **Remove the hazard completely so that the risk does not need to be controlled**

3.2.4 Land Use

Whilst the Site States strategy describes the condition to which designated land and associated structures and infrastructure need to be restored, Land Use is about understanding how sites can be used following the end of decommissioning or during interim periods between decommissioning and remediation activities.

There are three options for Land Use:

1. **Retain land as an NDA asset / liability**
2. **Retain land on behalf of government as a national asset**
3. **Divest the land (leasehold or freehold) for social, environmental or economic benefit**

3.3 Spent Fuels

Within the Spent Fuels theme, there are three individual topic strategies, reflecting the three groups of spent fuels for which the NDA is responsible. Spent fuel is fuel that has been used in a nuclear reactor.

3.3.1 Spent Oxide Fuel

Oxide fuel is a type of fuel used in advanced gas-cooled reactors (AGRs) and pressurised water reactors. The two credible options available for managing spent oxide fuel are:

1. **Continued interim storage of fuel in existing facilities pending treatment and packaging prior to disposal to a geological disposal facility (GDF) (baseline scenario)**
2. **Build new storage facilities and interim store pending treatment and packaging prior to disposal to a GDF (credible alternative option to be assessed in detail)**

3.3.2 Spent Magnox Fuel

Magnox fuel is the type of fuel used in Magnox reactors. Three credible options were assessed for managing the remaining inventory of spent Magnox fuel:

1. **Continue as planned, maximise the reprocessing of suitable spent Magnox fuel prior to ending operations around the end of the 2020/21 financial year. Interim store remaining material pending treatment and packaging prior to disposal to a GDF (baseline scenario).**
2. **Stop reprocessing of suitable spent Magnox fuel early and interim store the remaining material pending treatment and packaging prior to disposal to a GDF (credible alternative option assessed in detail).**
3. **Extend reprocessing operations to ensure all suitable spent Magnox fuel is reprocessed and interim store Magnox spent fuel not suitable for reprocessing pending treatment and packaging prior to disposal to a GDF (credible alternative option assessed in detail).**

3.3.3 Spent Exotic Fuel

Exotic fuel covers a range of minor fuel types, such as those used in experimental reactors. Exotic spent fuel management options differ from the options for Magnox and Oxides, primarily due to the unique nature of the inventory, which has mostly been produced from experimental research into nuclear reactor technologies. Within the inventory, there are several different forms of exotic spent fuel. However, the high-level strategy for exotic fuels is similar to that for all NDA fuels, which is to consolidate, interim store and eventually dispose (pending a decision on the appropriate disposal facility). The consolidation of exotic fuels is currently continuing across the NDA estate

Work to identify and develop credible options for the disposition of spent exotic fuels that cannot be managed using existing facilities was ongoing at the time of writing the 2016 IIA. Therefore, it did not identify credible options for these fuels. However, since 2016, credible options for the ongoing management of exotic spent fuels have been identified and developed. No decisions have yet been made on the long-term management options for exotic spent fuels, although only a small quantity will need bespoke solutions. The rest will be managed alongside Magnox and AGR fuels. The following credible options have been identified for each of the different exotic spent fuels:

1. **Consolidate exotic spent fuels at Sellafield, and interim store in existing or modified facilities pending treatment and packaging prior to disposal in a GDF.**
2. **Consolidate exotic spent fuels at Sellafield, build new storage facilities and interim store pending treatment and packaging prior to disposal in a GDF.**

3.4 Nuclear Material

This strategic theme comprises plutonium and uranium. As these materials could still be used, for example as fuel for new reactors, they are not automatically considered waste. It sets out the NDA's approach to dealing with the inventory of nuclear materials stored on some of its sites.

3.4.1 Plutonium

Three credible options exist for managing the NDA inventory of civil plutonium:

1. **Continued safe and secure storage, renovating and replacing stores as required** (baseline scenario)
2. **Build facilities to make fuel to enable use in a third-party reactor prior to storage and disposal to a GDF** (credible alternative option assessed in detail)
3. **Build facilities to condition and treat plutonium prior to storage and disposal to a GDF** (credible alternative option assessed in detail)

3.4.2 Uranium

The credible options for managing the uranium inventory are:

1. **Continued safe and secure storage pending sale for reuse**
2. **Continued safe and secure storage pending conditioning to an appropriate form for disposal**

3.5 Integrated Waste Management

The Integrated Waste Management theme considers how the NDA manages all forms of waste arising from operation and decommissioning of its sites. The strategy is broken down into: Radioactive Waste, Liquid and Gaseous Discharges and Non-radioactive Waste.

3.5.1 Radioactive Waste

The NDA Strategy for radioactive waste management covers two groups of radioactive waste: HAW and Solid LLW.

Higher-activity Waste (HAW)

HAW includes HLW, ILW and a relatively small volume of LLW that is unsuitable for management under the *UK Strategy for Management of Solid LLW from the Nuclear Industry* [5], in most cases because of the nature of the radionuclides contained in the waste.

In England and Wales, the government policy is for HAW to be disposed of in a GDF and using alternative disposal systems. The Scottish government policy is that the management of higher activity radioactive waste should be in near-surface facilities. As the NDA's strategy is selected to meet the requirements of these policies, there is no strategic decision for the NDA to make (although the NDA works closely with government to identify and develop solutions). The NDA's strategic position for the management of HAW is to comply with and deliver these government policies.

As the initial stage of the HAW management route is fixed (i.e. retrieve the waste from the sites) and the end stage is also fixed (i.e. geological disposal or alternative disposal systems in England and Wales and near-surface management in Scotland), the intermediary stage must involve some form of treatment, conditioning and / or packaging to make the waste suitable for disposal. From an NDA perspective, it is during this stage that there is the greatest scope for strategic decision-making.

Credible management options available during this stage revolve around two issues:

- where the waste is stored; and
- where the waste is treated.

The assessment has considered the treatment and storage of HAW, for which there are three credible options:

1. **Storage / treatment at local (on or near-site) facilities**
2. **Storage / treatment at regional facilities**
3. **Treatment at national facilities**[4]

Solid LLW

The NDA strategy for managing solid LLW, including VLLW, is consistent with the UK Nuclear Industry LLW Strategy [5]. Therefore, from an NDA perspective, there are no strategic decisions to make and no credible options require assessment as the UK Nuclear Industry LLW Strategy has been assessed separately.

[4] Storage of wastes in a single national facility is not considered to be credible owing to the existence of numerous suitable storage facilities across the country.

3.5.2 Liquid and Gaseous Discharges

In June 2009, the UK government published its revised *UK Strategy for Radioactive Discharges* to inform decision-making by industry and regulators [6].[5] This sets out how the UK will implement its obligations under the OSPAR Radioactive Substances Strategy 2020 intermediate objective [7]. As the NDA has a significant role in the development and implementation of the *UK Strategy for Radioactive Discharges*, a separate strategy for the NDA estate is not required.

3.5.3 Non-radioactive Waste

The UK has a well-established, comprehensive and prescriptive regulatory regime for the management of non-radioactive waste. Waste management strategies have been developed at national, regional and local levels by the UK government, devolved administrations and local and regional authorities. The NDA has collated the established practices and principles that underpin these strategies and implements them across its estate.

[5] The strategy was reviewed by the Department for Business, Energy and Industrial Strategy (BEIS) in 2018 [8] and it was concluded that good progress against the targets has been made; the strategy was not updated.

4.0 Approach to Assessment and Methodology

4.1 Introduction

The IIA of NDA Strategy (2021) comprises the combined results of an SEA,[Error! Bookmark not defined.] HIA and SeIA. Each assessment has been completed by relevant specialists, with ongoing dialogue to ensure consistency and effective information sharing across them. The results of both the SEA and SeIA have been used to inform the HIA.

4.2 Requirements of SEA, SeIA and HIA

4.2.1 Strategic Environmental Assessment (SEA)

The NDA is committed to ensuring that the development of its Strategy is in accordance with the requirements of the European Union's SEA Directive and transposing UK Regulations.

SEAs became a statutory requirement following the adoption of European Directive 2001/42/EC (the SEA Directive) *'on the assessment of the effects of certain plans and programmes on the environment'*. The SEA Directive was transposed into UK legislation on the 20 July 2004 as *Statutory Instrument No. 1633 – The Environmental Assessment of Plans and Programmes Regulations 2004* ("the SEA Regulations").

4.2.2 Health Impact Assessment (HIA)

NDA Strategy (2021), which covers activities at each of the 17 sites that make up the NDA estate, could have potential effects on public health. In order to understand the potential risks for health effects associated with the Strategy, an HIA has been undertaken.

By incorporating the HIA into the IIA, the NDA is aiming to implement good practice and integrate the HIA into its strategic decision-making.

4.2.3 Socio-economic Impact Assessment (SeIA)

Employees at NDA sites generally number in the hundreds. Given their largely remote locations, this makes many of the sites important providers of employment and contributors to the local and, in some cases, regional economy. Changes at the sites as they move through their respective decommissioning programmes therefore have the potential to affect the socio-economic characteristics of local communities, particularly by affecting those directly employed at the sites and organisations in the sites' supply chains.

The potential for the NDA Strategy to have socio-economic implications is a key consideration in its development, as underlined by a requirement in the Energy Act (2004). By incorporating an SeIA into the IIA, the NDA is aiming both to implement good practice, by giving due regard to socio-economic considerations, and to integrate the SeIA into its strategic decision-making.

4.3 Geographic Scope

The geographic scope of the assessment covers the UK, as the 17 sites which comprise the NDA estate are spread across these countries with the exception of Northern Ireland.

Anything beyond the geographic scope set out in policy has been considered beyond the scope of the assessment – for example, the storage and disposal of HAW using international facilities.

The Baseline Report (contained in Volume 3 of the IIA Report) uses a geographic boundary of between 100 m and 5,000 m around each site for topics considered at a local scale.

4.4 Temporal Scope

It is assumed that the Strategy will be in operation until the final site in the NDA estate achieves its stated end state. This is anticipated to be Sellafield in the year 2120. However, it is also assumed that the Strategy will be reviewed and updated on a 5-year cycle throughout this period.

It is important to note that, in reality, such dates are not fixed, as new technologies may be developed which speed up decommissioning programmes. Similarly, unforeseen circumstances may extend decommissioning timescales.

The exact timescales over which impacts will occur is uncertain. The NDA Strategy covers the next hundred years and it is difficult to assess how the strategy will develop over this timescale or what its effects will be. Therefore, the results in this IIA are only indicative..

4.5 Key Assessment Steps

To perform the assessment, a set of key steps was used. These were:

1. identify the risks of (or opportunities arising from) the effects of the strategic options identified in the Strategy, and how they might occur;
2. identify any existing measures to meet legislative requirements and existing forms of mitigation across the NDA estate which may already address the risks;
3. where the risk of (or opportunity arising from) an effect remains, assess the potential significance (based on the magnitude of the effect and the sensitivity of the receptors), where possible taking into account uncertainties and factors which may cause the significance to vary;
4. recommend further mitigation and enhancement measures; and
5. recommend monitoring and response mechanisms.

For some options, insufficient information was available to conduct step 3. Instead, assessment of these options focused on identifying and discussing environmental, socio-economic and health effects and their management and mitigation, as well as opportunities for potential benefits.

4.6 Proposed Assessment Framework and Guide Questions

In order to support the IIA, guiding questions were used to cover the range of environmental, health and socio-economic issues relevant to the assessment. These questions are the same as were used in the IIA of the last Strategy (2016).

The assessment guide questions used in the IIA can be found in IIA Report: Volume 1 – Appendix B.

4.7 Assumptions and Uncertainties

To support the assessment and ensure transparency and robustness, a set of assumptions and uncertainties have been documented in a register. The register is presented in IIA Report: Volume 1 - Appendix A.

4.8 Response to Informal Scoping Consultation

The IIA of Strategy (2016) has been reviewed and updated to reflect Strategy 2021. As the IIA was updated rather than produced as a new document, a scoping workshop was not held. Instead, a scoping report was produced summarising the planned changes to the IIA and circulated to representatives of Statutory Consultees in an informal review process. Review comments were collated and addressed in the updates made to the IIA.

Some of the main points raised by the reviewers, and the actions taken to address them, are listed in the following points.

- It was suggested that flora should be added as a receptor under the landscape assessment topic.
    - **Action taken –** flora was added as a receptor.
- A number of additional references were recommended for use in updating the IIA. These included, for example, Dynamic Coast project reports [9], Scotland's *Landscape Character Assessment* [1010], the *State of Nature* Scotland Report [11], the UK *State of Nature Report* [12], the *Nature Networks Evidence Handbook* [13] and the 25 Year Environment Plan [14].
    - **Action taken –** the suggested sources were used in the relevant reports.
- The requirement for biodiversity net gain was not referenced consistently throughout the scoping report.
    - **Action taken –** the requirement for biodiversity net gain was incorporated in Volumes 1 and 3 of the IIA.
- It was suggested that extreme heat, drought and subsidence could be considered with respect to climate change.
    - **Action taken** – Although it is too early to assess impacts of these issues on the NDA Strategy, it has been recommended (Volume 3, Section 4.3.2) that these issues might be considered in future IIAs for future NDA Strategies
- It was noted that some NDA sites are valued as a result of their iconic design or appearance.
    - **Action taken –** this has been added to consideration of Cultural Heritage.
- Changes to text regarding land use were suggested to include agricultural land quality.
    - **Action taken –** the suggested text was added to Volume 1 of the IIA.
- It was noted that some temporary landscape or visual impacts could occur during decommissioning.
    - **Action taken –** text on landscape and visual impact was added to cover temporary impacts during decommissioning.

5.0 Integrated impact assessment of the NDA Strategy (2021)

5.1 Introduction

This chapter presents the findings of the IIA. It explains the risks and opportunities arising from the environmental, socio-economic and health effects of the NDA Strategy (2021). It is split by theme and topic.

5.2 Site Decommissioning and Remediation

5.2.1 Decommissioning

Decommissioning involves decontamination and full or partial dismantling of facilities following the end of operations and the removal of operational material and waste (sometimes known as post-operational clean out). The approach to decommissioning is developed on a case-by-case basis, reflecting the specific nature of the facility in question. The NDA estate includes reactors, chemical plants, research facilities, waste management facilities, and fuel fabrication and reprocessing plants, all of which present different decommissioning challenges.

Strategy (Preferred Option)

The NDA's strategy is to decommission its sites as soon as reasonably practicable, taking account of lifecycle risks to people and the environment and other relevant factors. There are three broad credible options for implementing this strategy, with each option being preferred under specific conditions. There are three broad credible options for implementing this strategy, with each option being preferred under specific conditions. These are decommissioning at a pace, decommissioning slowly without interruption, and deferred decommissioning, where decommissioning may pause for a time to allow radioactive contamination to decay, reducing the radiological risks during decommissioning. Generally, the NDA's preference is to not defer decommissioning, except where there are clear benefits from deferring work. Where deferred decommissioning is preferred, there needs to be a clear and well documented case for this.

Potential Effects

Environmental Risks and Opportunities

Decommissioning at a pace offers an environmental opportunity in terms of reducing the hazard and risks associated with land and facilities most quickly. This allows access to subsurface contamination, which can then be managed more efficiently. This could lead to short-term improvements to the landscape and air and water quality. Additionally, decommissioning at a pace can make use of existing infrastructure which might otherwise need to be maintained or upgraded if decommissioning were to be deferred. Decommissioning more slowly would still offer these benefits, but hazard reduction and improvements to landscape and air and water quality would be realised over a longer timeframe than if a site was decommissioned at a pace.

In some cases, deferring decommissioning can provide an opportunity to allow natural radioactive decay, which reduces the radiological risk to the public and the environment during decommissioning and may reduce the level of physical activity needed to clean up a site or facility. This reduction in physical activity may reduce environmental impacts such as noise and vibration, air and water pollution. If there are short-lived radionuclides, then deferred decommissioning may reduce the waste management burden, with potential knock-on implications in terms of reduced transport. Decommissioning slowly could also enable these benefits to be realised, depending on the order in which facilities were decommissioned.

The use of deferred decommissioning is highly dependent on site-specific considerations, such as the nature of the contamination and the facilities being decommissioned. It may not always be suitable, in which case such opportunities may not be realised.

Decommissioning at a pace could put a strain on waste management and storage facilities, as greater volumes of waste would arise in the short-term. These would need to be disposed or stored until an appropriate disposal facility was available. There may also be some strain on waste management and storage facilities from slower decommissioning (without a period of deferral), depending on the order in which facilities are decommissioned and the type of waste generated. Slower and deferred decommissioning may allow more time to plan appropriate management routes for waste generated, as well as allowing transport movements to be spread out over time. However, there may be a trade-off in terms of extended duration of impacts on land use and the landscape, particularly in the case of deferred decommissioning due to the period of deferral.

Socio-economic Risks and Opportunities

Decommissioning slowly without interruptions offers opportunities in terms of maintaining a skilled workforce and jobs in the supply chain. It can also mean that land becomes available for alternative uses more quickly than if decommissioning is deferred. Decommissioning at a pace would make land available for alternative uses soonest. Such uses may include supporting new facilities or providing some other form of socio-economic or environmental benefit (see Section 5.2.4).

A key socio-economic risk associated with decommissioning at a pace is the potential for skills and the workforce to be ‘locked up’ on a particular site or area of a site. This may prevent other sites or areas receiving attention, which could have further implications from an environmental and health perspective. This may also occur if a number of sites are being decommissioned slowly over the same time period.

A risk associated with deferred decommissioning is the potential for jobs and skills to be lost during periods of deferral due to a decline in demand. However, deferred decommissioning would offer the opportunity to maintain some jobs and the possibility of reusing facilities during the deferral period.

Health Risks and Opportunities

Under the decommissioning at a pace option, it is likely that more intensive activity would be required to clean up the site or facility. This could lead to higher magnitude environmental impacts in the short term, which may have implications for health. Intensive demolition or excavation works, for example, could result in changes in air quality, which might lead to slightly increased risks of cardiovascular and respiratory illnesses amongst the local population.

Decommissioning more slowly without interruption and deferred decommissioning may provide opportunities to spread out environmental impacts (and associated health impacts) over time, but at the risk of incurring negative effects on mental health and well-being due to extended impacts on the landscape and land use. As deferring decommissioning allows time for radioactive decay, doses received by workers may be lower (noting that in either case doses to workers will be managed and minimised as far as reasonably practicable). It may also be possible to reduce worker doses during slower decommissioning by planning to decommission some facilities later in the schedule to allow time for radioactive decay.

Maintenance of jobs over a longer period of time under the slower and deferred decommissioning options could offer mental health and well-being benefits (although there would be a decline in jobs during periods of deferral under that option) and may enable attention (in terms of resources, skills and workforce) to be diverted to sites and facilities where health risks are higher. This could be considered an additional health opportunity of slower or deferred decommissioning.

Decommissioning at a pace could have a negative impact on workers’ and their families’ mental health and well-being, as once a site is decommissioning the workforce is no longer required there, so workers would have to relocate to other sites or seek employment in a different industry. Decommissioning slowly and deferred decommissioning may also require workers to relocate, depending on the decommissioning programme, with associated mental health and well-being impacts on workers and their families.

Alternatives

As all three decommissioning approaches are considered to be preferred options under certain conditions, there are no alternative credible options requiring assessment.

5.2.2 Land Quality Management

The Land Quality Management topic involves managing risks to people and the environment from radioactive and non-radioactive contamination in the ground and groundwater. This is done through prevention and remediation (including control and monitoring).

Decisions over how remediation is carried out, including whether contaminated land is treated *in situ* or *ex situ*, are made on a case-by-case basis taking into account a range of relevant factors. Such factors include the nature of the contamination, the risks to people and the environment and the site interim and end state (see Section 5.2.3).

Strategy (Preferred Option)

Risk to people and the environment is the NDA's primary and enduring consideration in deciding how to manage land contamination. This risk is determined in part by the nature, extent and likely behaviour of any contamination.

The NDA strategy is to employ early, risk-based decision making to ensure remediation is proportionate to the level of risk. At higher levels of risk, there is less flexibility in the way land quality is managed. Often the decision is driven by the need to reduce risk. Action will be taken as soon as reasonably practicable to minimise the time at risk. As levels of risk decrease, the strategy is to take account of sustainable development to promote socio-economic opportunities and maximise environmental protection.

Due to decisions being taken on a case-by-case basis, there is no single preferred option for this strategy. Instead, there are four credible options which may each be preferred under certain conditions.

Potential Effects

Environmental Risks and Opportunities

In situ management without intervention, due to the minimal activities required, has very few environmental risks; providing it has first been established that the contamination is not spreading or getting worse. As the contamination would be left where it is to allow natural attenuation[6] to take place, there would be very low energy use and waste generation, few vehicle movements and little pollution. However, use of the option is highly dependent on the nature of the contamination being correctly understood and whether potential pathways exist which might lead to effects on receptors (people, water, flora and fauna). As such, this option may not always be suitable. In the event that the contaminant does not attenuate naturally and remains in a relatively unchanged form for an extended period of time, there would be very few long-term environmental opportunities offered by this option in terms of improving land quality.

In situ management with intervention offers opportunities in terms of improving land quality and avoids many of the adverse environmental effects (such as air and noise emissions) associated with options that include excavation. Such opportunities may come with a trade-off in terms of environmental risks in the short and medium term. For example, intervention could involve processes which use energy and generate pollutant emissions. Intervention also involves disturbing contaminants and may increase the risk of contaminants spreading or being released.

Ex situ management for reuse would have short-term impacts associated with excavation activities. This may include transport of plant and equipment, energy use and emissions of air pollutants. Energy may also be used in treating excavated material. The main environmental opportunity offered by the *ex situ* management for reuse option is the avoidance of waste, which under the disposal option would

[6] By 'natural attenuation', we mean a reduction in the hazard posed by the contamination over time. This could be a result of radioactive decay, natural chemical and biological processes or dispersion of the contamination.

require transport to an authorised site. Reusing existing material may also help to reduce material requirements for other developments at a site. This could have environmental implications in terms of avoiding transport movements and carbon emissions.

Ex situ excavation for disposal is the option with the greatest environmental risks, as there would be short-term impacts from changes in air quality, noise and vibration, and landscape from the excavation activities, followed by longer-term impacts of transporting wastes to suitable disposal facilities.

Socio-economic Risks and Opportunities

From a socio-economic perspective, *in situ* management without intervention offers the least socio-economic opportunities, as employment would largely be restricted to monitoring activities. There would also be few opportunities to enhance knowledge and skills or provide education and training.

In contrast, *in situ* management with intervention would provide a range of opportunities to enhance knowledge and develop skills, although the extent of these opportunities would largely depend on the intervention technology used. There may also be opportunities for education, training and employment.

In situ management with intervention gives greater control over timescales than management without intervention, which can help free up land for alternative uses more quickly.

Ex situ management for reuse and *ex situ* excavation for disposal would each create employment and may lead to economic investment, but would be unlikely to create many opportunities in terms of enhancing knowledge and skills or education and training.

Finally, removing contaminated material from the ground can provide greater control over timescales, allowing the land to be freed up for alternative uses more quickly (see Section 5.2.4).

Health Risks and Opportunities

All options would offer health opportunities as the hazard would be removed or reduced. Intervention and excavation potentially offer the most opportunities from a health perspective, as the time at risk is reduced. However, there is a trade-off in terms of short-term environmental impacts which may influence health. For example, works to excavate contaminated material and transport it off-site could lead to changes in air quality which might influence the risk of cardiovascular and respiratory illnesses, while increased traffic might influence the risk of road accidents on the local transport network.

Alternatives

The four credible options outlined above may each be considered preferred under specific conditions and could all be used to implement the NDA strategy. Therefore, there are no other options requiring assessment.

5.2.3 Site End States

The NDA owns significant quantities of land, of which around one quarter is designated land that has been assigned by the government for decommissioning and remediation. As part of its responsibilities to government, the NDA is required to propose the end state for the designated land at each of its sites. The site end state describes the condition to which the site (land, structures and infrastructure) will be taken and, where necessary, should be accompanied by a description of the controls required to protect people and the environment from any residual hazards.

Site end states define objectives for the ongoing management of structures, infrastructure and land quality. They also have implications for the management of spent fuels, nuclear materials and waste arising from operational and decommissioning activities.

Since Strategy (2016), the NDA has worked with regulators and the government to ensure that the regulatory regimes in the UK are flexible enough to accommodate a range of end states and that residual controls do not restrict future use of land unnecessarily. Significant progress has been made, including the publication of the *Guidance on Requirements for Release from Radioactive Substances Regulation* [15] by the environment agencies and discussion of amendments to the *Nuclear Installations Act 1965*.

Strategy (Preferred Option)

The NDA strategy is to employ pragmatic, risk-based remediation objectives that enable beneficial reuse of sites wherever possible. This recognises that there may be both risks and opportunities associated with decommissioning and remediation activities. In some cases, there may be a tipping point beyond which remediation does more harm than good.

As a site gets closer to the end of its decommissioning process, the end state will need to be defined in increasing levels of detail. As far as possible, this should be informed by a clear view of the future land use to ensure the safety of future users and maximise beneficial reuse of structures, infrastructure and land (see Section 5.2.4).

The NDA's preferred option to achieve this strategy is to take its sites, on a site-by-site basis, to a condition suitable for their next planned use (in line with relevant planning requirements) or their probable future use(s) where remediation occurs before the next use is planned.

Potential Effects

The next-planned-use option ensures that the level of intervention (taking into account the cost, energy use and risk to workers) and the volume of waste generated are appropriate (no more or less than required) to meet the requirements of the site's next planned use. Whilst this can help to ensure that environmental, health and socio-economic risks are minimised, the exact nature and extent of risks (and therefore impacts) will be dependent on the next planned use and the activities needed to make the land suitable for it.

Environmental Risks and Opportunities

Activities required to make land suitable for the next planned use are likely to generate a range of short- to long-term environmental impacts, including changes in air, water and soil quality, the generation of carbon emissions and wastes, and changes to habitats or landscape. The exact extent of such impacts and whether they were a risk or opportunity would depend on the next planned use and the current state of the land. For example, in order to make the land suitable for use as a car park, the extent of physical activity (and thus the magnitude of associated environmental impacts) may be reduced when compared to making the land suitable for use as a residential development. There would be various environmental opportunities, including opportunities to remove contamination, improve long-term air, water and soil quality at the site, enhance biodiversity and remove structures or facilities which have adverse landscape and visual impacts.

Socio-economic Risks and Opportunities

Under the preferred option there would be opportunities to enhance knowledge and develop skills. Regardless of the next planned use for a site, a degree of remediation may need to take place to make the site safe. Generally speaking, the greater the extent of intervention required, the greater the opportunities may be for developing knowledge and skills and promoting education and training, though this is not always the case. Such intervention would generate employment.

A further socio-economic opportunity associated with this option is the potential for reuse or divestment of the land which, following remediation, may become a local or national asset.

Health Risks and Opportunities

The main health opportunity associated with taking sites to a condition suitable for their next planned use is the removal of hazards which may affect land, water and air quality. Removal of such hazards may also free the land up for alternative uses, which could include amenity or recreational features. Creation of such features could increase levels of physical activity undertaken by the local population, thereby providing health benefits.

Remediation of a site to a condition suitable for its next planned use has the potential to generate adverse environmental impacts in the short to medium term, though these would be reduced compared to making a site suitable for any foreseeable use. Such impacts could have adverse implications for health. For example, an increase in air pollutant emission could influence the risk of cardiovascular and respiratory illnesses amongst the local population.

Making land suitable for its next planned use may offer further opportunities to facilitate dialogue with stakeholders, which can have a positive effect on community cohesion and may lead to mental health and well-being benefits.

Alternatives

Leave the Hazard Where it is and Prevent Use

This option would not involve physical activity to improve the condition of the site, but may involve minimal activity to maintain, stabilise it or prevent further contamination. For the most part, it would rely on controls (legal or administrative tools or actions such as restrictions on land use, environmental monitoring requirements, and site access and security measures) to manage risks to people and the environment.

This option is only suitable in extreme cases where remediation is very difficult and turning the site into a disposal site (that needs to be managed by preventing use) is preferable to attempting extensive and costly remediation in order to create a new facility or alternative land use.

Managing the risk using controls could offer some opportunities from an environmental perspective in terms of reducing the physical activity needed in the short and medium term (and therefore the magnitude of impacts). This might include avoiding pollution-generating activities such as excavation, vehicle movements and energy use.

Under this option, no environmental opportunities would be realised in terms of improving water and soil quality at the site in the long-term. The hazard would also still exist in a relatively unaltered form (although monitoring would be used to ensure risks did not increase). This could have potential health implications.

Preventing the site from being reused would limit socio-economic opportunities but may lead to some employment to undertake monitoring activities.

Remove the Hazard Completely so that the Risk Does not Need to be Controlled

Under this option, the site would be restored to a condition where it can be used for any foreseeable use without the need for additional remediation or management controls. The level of intervention required to achieve this would likely exceed that required under the other two credible options.

This may mean that environmental impacts (both adverse and beneficial) associated with intervention activities are greater. For example, removing the hazard completely would likely lead to high-magnitude adverse impacts in terms of air quality, noise and vibration, carbon emissions, energy use and waste in the short to medium term, but may result in long-term improvements in air, water and soil quality, as well as positive habitat, landscape and visual impacts. It is also likely that greater volumes of waste would be generated that may then need to be removed from the site.

Due to the increased level of intervention required to make the land suitable for any foreseeable use, there may be a range of socio-economic opportunities provided, including employment, development of skills and opportunities for education and training. Such opportunities could have positive health effects in terms of mental health and well-being. On the other hand, removing the hazard completely would likely take longer, and thus the land would not be made available for reuse as early as it would be under the next-planned-use option. This could limit the attainment of socio-economic opportunities such as investment into the local economy and jobs.

From a health perspective, removing the hazard completely may offer greater long-term health opportunities than the two other credible options, depending on the disposal route. However, in the short to medium term, the greater level of intervention required could increase health risks as environmental impacts would likely be of higher magnitude.

5.2.4 Land Use

The NDA's Site End States strategy describes the condition to which designated land and associated structures and infrastructure need to be restored. In support of this, its Land Use strategy explores how land can be used either following completion of decommissioning and remediation activities or on an interim basis prior to achieving the site end state.

Strategy (Preferred Option)

The NDA strategy is to identify credible uses for its land either when decommissioning and remediation is complete or on an interim basis prior to achieving the site end state. Part of this commitment is an aspiration to encourage the reuse of brownfield land over greenfield land, in line with government policy.

The NDA is committed to investigating reuse opportunities, recognising that there is a need to balance the cost of achieving an end state against the socio-economic or environmental value the next use will bring.

Whilst the NDA's preferred option is to divest the land for some benefit, it is recognised that there may be situations in which the land may need to be retained as a government asset or as an NDA liability.

Potential Effects

Environmental Opportunities

Decommissioning and clean-up of sites may facilitate development of new nuclear build. This could offer a number of environmental opportunities, including the avoidance of environmental impacts associated with development of new sites. Such development at existing sites would also offer opportunities by providing a low-carbon, low-land-footprint form of power generation, which could have a positive impact from climate change and landscape appearance perspectives.

Environmental opportunities may be provided if sites are converted into nature conservation sites or habitats. This could help to promote biodiversity and improve local landscapes.

Socio-economic Opportunities

Clean-up and closure of the NDA sites may provide socio-economic opportunities if a community service or facility can be established. This might include a business park or some other facility which provides benefits to the local economy. Such development would likely support employment and could lead to opportunities to enhance knowledge and skills.

Development of a college or research establishment could promote opportunities for education and training. An example of this is the transfer of some of the research facilities at Berkeley Centre (owned by the NDA and adjacent to the Berkeley reactor decommissioning site) to South Gloucestershire and Stroud College with a view to providing training in the renewable energy and nuclear sectors.

If land is used to support the new generation of nuclear build this could provide an opportunity to create a national asset, providing jobs and economic investment into the community or region.

Health Opportunities

Creation of recreational or amenity space or some other form of community facility could lead to health opportunities from improvements in mental health and well-being, as well as having positive physical health implications if it leads to increased levels of physical activity.

In addition, the actual process of determining a future land use in itself may offer health opportunities if it promotes community cohesion through an effective stakeholder consultation process.

Alternatives

The alternative credible options to divesting the land for some socio-economic or environmental benefit are to either retain the land as a government asset or to retain the land as an NDA liability. Such options would offer little in the way of opportunities, and would only be preferred in the event that a more suitable use could not be identified.

5.3 Spent Fuels

5.3.1 Spent Oxide Fuel

Oxide fuel is used in Advanced Gas-Cooled Reactors (AGRs) operated by EDF Energy in the UK, and in light-water reactors operated by numerous utilities throughout the world. Spent oxide fuel has historically been reprocessed in the Thermal Oxide Reprocessing Plant (THORP) at Sellafield, which started operation in 1994 and ceased in 2018.

The NDA has contractually committed to receive and manage all the spent fuel arising from the seven currently operating EDF AGR power stations in England and Scotland. EDF has publicly declared its intention to operate these stations for as long as it is safe and economic to do so and to seek significant life extensions for them. Given the cessation of AGR spent fuel reprocessing in THORP, the remainder of this spent fuel is to be placed into interim storage pending a future decision over its long-term management.

Strategy (Preferred Option)

In the previous Strategy the NDA committed to reprocess the contracted amount of spent fuel in THORP, completing THORP reprocessing as soon as practicable, while interim storing, immobilising and then eventually disposing of any unreprocessed spent fuel to a GDF.

Reprocessing at THORP has now ceased, and re-opening THORP is no longer deemed a credible option. As such, in delivering the current strategy, the NDA seeks to continue with the preferred option from the previous Strategy: to store, immobilise and dispose of unreprocessed spent oxide fuel to a GDF. As the disposal end point is viewed as fixed, the only strategic decision to be made by the NDA is whether to store spent oxide fuel in existing or new storage facilities. The preferred option is to store spent oxide fuel in current facilities at the Sellafield site, namely in the THORP Receipt and Storage facility.

Potential Effects

Environmental Risks and Opportunities

Managing the spent oxide fuel inventory through existing storage facilities avoids most of the short-, medium- and long-term environmental impacts associated with construction, operation and decommissioning of a new facility to store the inventory. These impacts may include emissions of air pollutants, noise and vibration, landscape and visual impacts, energy use and consumption of raw materials. Some construction may still be required to maintain existing stores and will be required to build a packaging plant to enable disposal of the unreprocessed spent fuel. However, such a packaging plant would be required in any case if constructing new storage facilities.

Operation of the packaging plant (which is required under both options) could generate a number of environmental impacts, particularly from a materials and waste perspective, as several thousand tonnes of spent oxide fuel would be packaged to produce a waste product.

Managing the spent oxide fuel in existing facilities may lead to slightly greater volumes of water abstraction, given the current wet storage of spent oxide fuels. However, any reduction in water abstraction as a result of constructing new facilities is likely to be small compared to water abstraction volumes for the site as whole. Managing the spent oxide fuel in existing facilities may also lead to slightly greater radiological discharges and operational waste volumes compared to newer facilities, because newer facilities would be optimised to reduce these disbenefits. However, given the current stringent controls on radiological discharges, which are very low, any reduction in discharges as a result of constructing new facilities would be small. In addition, construction of new facilities would lead to increased decommissioning waste volumes, which would likely dwarf any benefits in terms of operational waste generation.

There may be additional increased risk of corrosion of spent fuel stored in current storage facilities, which could lead to releases to the ground or water environments. Such risks, although low, would need to be carefully managed.

Socio-economic Risks and Opportunities

Under the preferred option, current jobs at the THORP Receipt and Storage facility would be maintained, however new jobs from construction of new facilities would not be created.

Considerable employment would be generated through construction of a packaging plant for the spent oxide fuels prior to packaging and disposal to a GDF. This would range from lower-skilled construction jobs to highly specialist engineering and managerial skills.

Management of the spent oxide fuels using existing facilities offers limited opportunities for developing new knowledge and skills, with the exception of the knowledge and skills that might be gained from implementing techniques to prolong the life of existing interim stores. This might lead to some minor opportunities for education and training.

Development of a packaging plant offers some minor opportunities to enhance knowledge and skills in the conditioning of radioactive wastes. Construction of the facility may also offer socio-economic opportunities by creating a national asset that could be used to manage other waste streams.

Finally, continued operation of the THORP Receipt and Storage facility and supporting infrastructure will maintain investment into the local economy in the short to long term. Opportunities for investment may be provided by construction and operation of the packaging plant, but such opportunities will not be as large as if new storage facilities were constructed.

Health Risks and Opportunities

In terms of health risks, construction activities required to develop a packaging plant could lead to short-term adverse changes in air quality, which might influence the risk of respiratory and cardiovascular conditions amongst the local population. Noise and vibration could possibly lead to annoyance and anxiety, while construction traffic could increase the risk of accidents on the local road network. There is also a risk of releases of non-radioactive contaminants to the ground and water environment, which could have further health implications, though these could be controlled through implementation of a construction environmental management plan. However, such risks would all be greater if new storage facilities were constructed.

This option may offer some health opportunities by avoiding the additional movement of the spent oxide fuel to a new facility prior to packaging and disposal to a GDF. These risks would include conventional risks associated with transport movement and air quality, but also the small radiological risk associated with movement of radioactive waste. Such radiological risks would likely be partially or fully offset by new facilities being built to more modern standards, and therefore offering a higher level of radiological protection. However, extensive controls are in place to manage radiological risks in existing facilities, so any radiological benefit from constructing new stores would be very small.

Avoiding the construction of new facilities would likely have mental health benefits through the avoidance of environmental effects, including reduced air quality, noise and vibration generation, and visual and landscape effects. However, construction of new facilities would lead to mental health benefits associated with employment opportunities. Overall, the effects on mental health of storing spent oxide fuel in existing facilities is likely to be small.

Alternatives

There is one credible alternative option to storing the oxides inventory using existing facilities, which is to store the oxides inventory in a new pond, cask store or dry store. The potential environmental, socio-economic and health impacts of this option compared to the baseline is considered in the detailed assessment presented in IIA Report: Volume 2 – Section 3.1.

5.3.2 Spent Magnox Fuel

The Magnox reactors were the first generation of commercial nuclear power stations to operate in the UK. All of these twenty-six reactors have now been shut down. The last remaining operating reactor at Wylfa ceased generating in December 2015.

The NDA has the responsibility to defuel and decommission all of these Magnox reactors. Prior to decommissioning, spent fuel was removed from reactor cores and sent to Sellafield for reprocessing.

Reprocessing was identified as the preferred option for managing Magnox spent fuel as the fuel and alloy in which it is encased are both susceptible to corrosion in water over time. Reprocessing allows the spent fuel to be broken down into its components of uranium, plutonium and waste.

Strategy (Preferred Option)

The NDA strategy is to reprocess all Magnox fuel in line with the Magnox Operating Programme (MOP 9) [16].

MOP 9 outlines the timeframes and targets for activities at Magnox sites. Detailed co-ordination of all activities ensures a smooth sequence of transport movements and efficient operation of the reprocessing facilities at Sellafield.

Reprocessing of spent Magnox fuel has been the UK's historic strategic position for over 50 years and remains the current preferred option.

Potential Effects

Environmental Risks and Opportunities

One of the main environmental risks associated with Magnox reprocessing is the potential for liquid and aerial discharges. These are managed in line with government targets, as set out in the *UK Strategy for Radioactive Discharges* [6].

There are a number of other environmental impacts associated with continuing to reprocess the Magnox inventory. These include the ongoing use of energy and generation of carbon emissions associated with equipment and the movement of workers, and the visual impact of the plant and stores on the landscape. These impacts are short-term as the plant is scheduled to be shut down at the end of the 2020/21 financial year.

Reprocessing spent Magnox fuel produces plutonium, uranium and High-Activity Liquor (HAL), all of which are radioactive and require careful management. Although there are appropriate management routes in place to deal with these products (see Sections 5.4.1 and **Error! Reference source not found.**), this could be considered an environmental risk from a radiological perspective. Indeed, extending Magnox reprocessing beyond the end of the 2020/21 financial year would exacerbate such risks, which are avoided under this preferred option.

There are also risks associated with the use of aqueous processes and solvents during the extraction of plutonium and uranium. The use of such processes can lead to risks of hazardous releases to water bodies. Given the extensive controls that are put in place to avoid, minimise and monitor releases of contamination to the water environment, any residual risks are generally small.

Such risks may also be offset somewhat by the opportunities that come from converting the spent fuel into a form less susceptible to corrosion. Long-term interim wet storage of spent Magnox fuel can lead to contamination and degradation of interim storage facilities; therefore, the baseline option is to store any unprocessed spent Magnox fuel in self-shielded boxes. A greater number of facilities to store such boxes would be required if Magnox reprocessing operations ceased early, whereas extended reprocessing increases the likelihood of significant maintenance being required if supporting plant fails (see 'Alternatives' section). As such, ceasing reprocessing at the end of the 2020/21 financial year balances the environmental risks and opportunities of avoiding construction and maintenance activities.

One of the main opportunities associated with ceasing reprocessing at the end of the 2020/21 financial year is the avoidance of continued operation of the Magnox reprocessing plant at decreased throughput rates, which would result from the attempt to reprocess the entire spent Magnox fuel inventory. Such extended reprocessing would be associated with significant energy usage and would delay the decommissioning of the Magnox reprocessing plant, with associated landscape and visual effects.

Ceasing reprocessing at the end of the 2020/21 financial year would also likely avoid the need for the construction of an additional self-shielded-box store that is assumed to be needed if reprocessing operations ceased early. Such construction would have a range of short-, medium- and long-term environmental impacts, including changes in air quality, noise and vibration, landscape and visual impacts, material and energy use and contamination of soil and water. These impacts are avoided under the preferred option. However, it is acknowledged, that the difference in impacts between the baseline option and ceasing reprocessing operations early narrows as the end of the 2020/21 financial year approaches.

Socio-economic Risks and Opportunities

Reprocessing spent Magnox fuel at Sellafield has brought, and continues to bring, economic investment into the local and regional economy. This investment may be both direct, and through supporting employment, which in turn has multiplier effects. Such economic opportunities would continue under this option until the end of the 2020/21 financial year, and perhaps for some time after this as the facilities are decommissioned, but would eventually decline.

From an employment perspective, continuing to reprocess the Magnox inventory will maintain jobs over the next few months. These jobs are associated with operation of the plant and stores, in addition to managerial and administrative positions that may be required to support reprocessing activities. Once Magnox reprocessing has ceased, and the facilities are shut down in preparation for decommissioning, these jobs will be lost. Some opportunities for job creation may exist to undertake decommissioning, which could help to offset some of these losses, as could the potential transfer of jobs to other facilities. Such employment changes may affect the nature of local communities and the local economy.

Ceasing reprocessing at the end of the 2020/21 financial year offers limited opportunities to develop new skills or knowledge. However, such knowledge and skills would likely be enhanced if reprocessing operations were extended to cope with more heavily corroded spent Magnox fuels.

Health Risks and Opportunities

The main opportunity provided by this option from a health perspective is the conversion of spent fuel into a form less susceptible to corrosion in storage. Such corrosion can lead to land and water contamination, which could have adverse health implications if not managed appropriately. However, as reprocessing generates HAL, a highly radioactive waste which requires careful management, overall there may be an adverse effect on radiological safety from continued reprocessing, though risks remain well within acceptable limits. Ceasing operations at the end of the 2020/21 financial year somewhat balances these competing effects.

If an alternative option were implemented to deal with the spent Magnox inventory, construction or maintenance activities would lead to environment-related health risks such as changes in air quality, noise and traffic.

Finally, the maintenance of jobs to operate the plant and stores until the end of the 2020/21 financial year may have a positive impact in terms of mental health and well-being, although this benefit is small compared to ceasing reprocessing operations early, and would be greater, but ultimately only extended temporarily, if reprocessing operations were extended.

Alternatives

There are two credible alternative options to ceasing reprocessing of suitable spent Magnox fuel at the end of the 2020/21 financial year. These alternative options are to cease reprocessing operations early, by a few months, or to extend reprocessing operations to ensure all suitable spent Magnox fuel is reprocessed. In both alternatives, any unreprocessed spent Magnox fuel or fuel that is not suitable for reprocessing would be placed in interim stores pending treatment, packaging and disposal to a GDF. The potential environmental, socio-economic and health risks associated with these alternative options are assessed in IIA Report: Volume 2 – Section 3.2.

5.3.3 Spent Exotic Fuel

In addition to bulk Magnox and oxide fuels, the NDA also manages a smaller inventory of non-standard fuels, commonly referred to as ‘exotics’. These fuels include metallic, oxide and carbide materials that have come from early nuclear industry activities such as the development of research, experimental and prototype fuels and reactors.

Some, but not all, of these fuels share common characteristics with bulk Magnox and oxide fuels, and can be managed in the same way, for example through reprocessing or through storage, immobilisation and eventual disposal. Some, however, present their own particular management challenges due to their diverse and sometimes unique properties. In some cases, tailored solutions for long-term management and disposition may be required.

Strategy (Preferred Option)

Where the properties of the exotic fuels share common characteristics with bulk fuels such as Magnox and oxides, it may be practicable and economic to manage them using the same facilities. The NDA has therefore identified that its preferred option is to continue managing the exotic inventory using existing facilities, reprocessing the spent fuels, where possible, alongside bulk fuels.

Any part of the inventory which cannot be reprocessed alongside bulk fuels will be stored pending availability of a GDF. In preparation for this, the decision has been made to consolidate these fuels at Sellafield. This consolidation is currently underway. Following consolidation, two options have been identified for these fuels: interim store in existing or modified facilities, or interim store in new facilities. The preferred option may vary with fuel type.

Potential Effects

Environmental Risks and Opportunities

For spent fuels that cannot be reprocessed or remain following closure of the reprocessing plants, the main difference between the options is the impact of constructing a new store compared to using or modifying an existing store.

Impacts of constructing new storage facilities include short-term changes in air and water quality and landscape and visual impacts. Noise may also be generated from vehicle movements and the use of plant which would require energy and could generate carbon emissions. Modifications to an existing store could cause similar impacts on a smaller scale.

Constructing a new facility rather than using an existing facility requires more resources. It would also generate more waste, as it creates an extra store to decommission once fuels have been transferred to the GDF. However, as the facility would be designed with decommissioning and the waste hierarchy in mind, the impact of this would be minimised as far as reasonably possible.

Socio-economic Risks and Opportunities

Construction of a new store would generate more construction jobs in the short-term than modifying an existing store. There would be a small contribution (in comparison to the impact of the whole Sellafield site) to the local economy during this period.

Under both options, personnel would be required to operate the stores and transport waste to a GDF when it becomes available. Appropriate education and training, and maintenance of knowledge and skills would be required.

Health Risks and Opportunities

Modifying an existing store may lead to higher worker doses than constructing a new store, as some radioactive material will already be in place in an existing store. A new store may have improved shielding compared to an older store, although it may be possible to improve existing shielding if required, and existing worker exposures are already managed and minimised within safe and legal guideline values.

Air quality and associated health impacts, such as increased risks of cardiovascular and respiratory illness amongst the local population, are likely to be worse under the new storage facilities option in the short-term whilst it is being constructed. Annoyance and road traffic impacts will also be greater at this time compared to if a store is being modified, although both options have an impact.

Both options require maintenance of jobs over a longer period of time, which could offer mental health and well-being benefits.

Alternatives

Where part of the exotics inventory is suitable for management alongside bulk fuels such as Magnox and spent oxide fuels, potential effects are covered under the assessments of those strategies (see Sections 8.3.1 and 8.3.2). There are a number of different types of exotic fuels, and which of the preferred options is selected for exotic fuel management may vary with each fuel type. There are no additional alternative options for managing the remaining exotic spent fuels, as the decision has been made to consolidate the fuels at Sellafield, and they will require disposal in a GDF due to their activity and heat generation. This consolidation process is underway, but not yet complete.

5.4 Nuclear Materials

5.4.1 Plutonium

On completion of reprocessing operations at Sellafield, there will be around 140 tonnes of separated plutonium from civil sources in the UK. This inventory will need to be managed in a way that renders the vast majority of UK plutonium beyond reach, in line with UK government priorities.

Strategy (Preferred Option)

In 2011, informed by NDA strategic options work, the UK government proposed a preliminary policy view to pursue reuse of plutonium, by converting the vast majority of the UK civil separated plutonium into fuel for use in nuclear reactors. Use of the plutonium as reactor fuel would reduce the proliferation risk, as the resulting spent fuel would be less accessible. Any remaining plutonium whose condition is such that it could not be converted into fuel would be immobilised and treated as waste for disposal.

As outlined in reference [17], reuse of plutonium is the preferred policy position, but there is currently an insufficient understanding of the options to confidently move into implementation. In the meantime, the NDA's strategy for plutonium stocks is to continue to safely and securely store them on its sites in suitable facilities in line with regulatory requirements.

The NDA continues to work with the UK government to develop strategic options for the implementation of its policy to render plutonium beyond reach. This work covers reuse, conditioning and treatment options. In any case, disposal to a GDF is the ultimate end point of the plutonium stocks, either after irradiation in a reactor or after suitable conditioning and treatment.

Option Description

Continued Safe and Secure Storage

The NDA's stocks of plutonium are contained in custom-built stores that ensure safe and secure storage. Over the past five years, the NDA has continued to retrieve materials from older stores and consolidate them in state-of-the-art facilities, such as the Sellafield Product and Residue Store (SPRS).

This option would involve continuing to store the plutonium inventory, repackaging the materials and replacing the stores as required. Generally speaking, the packages for the two different types of plutonium, Magnox and THORP, have 50- and 40-year lives respectively. There is a new facility at Sellafield which is designed to repack the Magnox plutonium packages to achieve 100-year storage life. Therefore, repackaging will be required according to the relevant package lifetime, or utilisation of the plutonium (whichever comes first).

Although some of the older storage facilities have limited life availability, the most modern plutonium store has been built to a "50 + 50" year life expectation (with the additional 50 years subject to regulatory approval). Additionally, there are plans to build extensions to the modern store to accommodate the plutonium that will be removed from the older stores over the next two decades, if required. This means that, as long as the materials continue to be stored pending development of a long-term disposition solution, there will continue to be ongoing maintenance activities and monitoring to ensure that levels of radioactivity stay well within legally acceptable limits.

Potential Effects

Environmental Risks and Opportunities

There are a number of environmental risks associated with maintaining the baseline scenario of continued safe and secure storage. These include the major landscape and visual impacts that come from the presence of the stores at the site and the air, noise and water-quality impacts resulting from activities to repackage the material and replace the stores on a periodic basis. It should be noted that such impacts are spread out over time, as the plutonium requires repackaging aligned to the package life and the modern stores are built to a "50 + 50" year design life.

There would be some ongoing energy use and carbon emissions associated with this option, when stores are constructed, for maintenance and monitoring activities and for ongoing vehicle movements to transport plutonium to the stores. Impacts from flooding are a further environmental risk with continued storage, as there is an ongoing potential for flooding at Sellafield. This risk may become more prevalent over time due to the effects of climate change, including sea-level rise, storm surges and other extreme weather events.

From a radiological risk perspective, plutonium decay in storage gives rise to alpha, neutron and gamma radiation, which can be hazardous to the workforce and requires careful management. If the stored plutonium was accidentally released, there would be a significant local (and potentially wider) environmental risk. Storage of the plutonium on a continuous basis would increase the time at risk, although the risk can potentially be mitigated by regular maintenance, monitoring and treatment activities.

Socio-economic Risks and Opportunities

Whilst continued safe and secure storage of the plutonium inventory prevents the land the stores are built on from being used for alternative purposes, construction, maintenance and repackaging activities do support ongoing employment. The current strategy of plutonium storage consolidation into modern stores reduces the overall footprint of stores on the site over time. This includes construction jobs, monitoring and management positions.

In terms of knowledge and skills, continued storage offers little in the way of opportunities. There are also limited opportunities to provide education and training.

A case could be made that the existing plutonium storage facilities constitute a national asset, providing a means to store the UK's civil plutonium stocks safely and securely. Storing the materials on a continuous basis would therefore preserve a national asset which could be used to store future arisings of plutonium.

Health Risks and Opportunities

Due to the build-up of alpha, neutron and gamma radiation over time, storing the plutonium on a continuous basis could be seen to have a negative impact in terms of radiological safety-related health risks. However, there are strict controls in place to monitor any changes in radiation levels, and any impacts would be appropriately mitigated to minimise radiological risks to people and the environment.

A number of health risks associated with this option are linked to environmental effects that would result from activities to maintain and replace the facilities. This might include changes in air quality which can influence the risk of respiratory and cardiovascular illnesses amongst the local population, as well as noise and vibration which can cause disturbance. As these effects would be spread out over time and would be relatively minor, any potential residual health risks would likely be minor or negligible.

Continued safe and secure storage offers very little in the way of health opportunities. Arguably the maintenance of jobs could be considered a minor benefit in terms of mental health and wellbeing, though this may be offset by negative impacts from the ongoing presence of facilities and hazardous material on the site.

Alternatives

Reuse

Although there is currently insufficient understanding of options to enable the preferred policy position of reuse to be implemented, the NDA continues to work closely with technology suppliers, developers and the UK government in order to establish how the reuse option could be secured and implemented.

For the purpose of this assessment, an assumption has been made that a fabrication facility would be required to convert the plutonium stocks into new nuclear fuel. The new nuclear fuel would then be transported to the reactors in which it is to be used.

The potential environmental, socio-economic and health effects of implementing the reuse option are considered in the IIA Report: Volume 2 – Section 4.1.

Condition and Treat

An alternative credible option to continuing to store, or reusing the plutonium as fuel, is to construct a suitable treatment facility or multiple facilities to convert the material into a safe form for disposal in a geological facility. This would also require construction of one or more suitable interim storage facilities.

The potential environmental, socio-economic and health effects of implementing the condition and treat option are considered in IIA Report: Volume 2 – Section 4.1.

5.4.2 Uranium

NDA's uranium has been produced from fuel cycle operations such as enrichment, fuel fabrication and reprocessing since the 1950s. Uranium is a nuclear material and is not usually classed as a waste, as uranium has the potential to be reused in nuclear fuel to generate electricity.

This assessment considers two main types of uranium. These are owned and strategically managed by the NDA and are uranium hexafluoride (UF_6), also known as 'hex' or 'tails', and Magnox depleted uranium (MDU), a product of spent fuel reprocessing. These are the two largest contributors (by mass) to the uranium inventory. The uranium in the UF_6 and MDU in the inventory is depleted.

Other types of uranium include highly enriched uranium (HEU), which is covered in the Exotics strategy, and THORP-product uranium (TPU).

Strategy (Preferred Option)

Owing to the diverse nature of the uranium material owned by NDA, there is no single preferred management option for the whole inventory. The preferred option therefore needs to be determined on a group-by-group basis.

There are two broad credible management options that might be chosen to manage a particular group of uranium materials. These are:

- continued safe and secure storage pending sale to a third party for recycling and reuse;
- continued safe and secure storage pending conditioning to an appropriate form for disposal.

The NDA continues to manage its uranium material in line with UK government policy.

Potential Effects

Environmental Risks and Opportunities

There are a number of environmental risks associated with the baseline scenario of continued safe and secure storage, which include the landscape and visual impacts of the existing stores and any pollution generated from maintenance activities required to repackage the material or replace the stores.

Material and waste impacts would be considerable for the disposal option, as this option would involve construction of multiple facilities, in addition to classifying approximately 50,000 tonnes of depleted uranium as waste. However, the sale of uranium to third parties would also ultimately lead to waste generation.

The construction impacts associated with disposal may include short-term changes in air and water quality and landscape and visual impacts. Noise may also be generated from vehicle movements and the use of plant; these would also require energy and could generate carbon emissions.

Environmental impacts associated with construction would be avoided under the sell option. This option would also offer opportunities in terms of landscape and visual impacts by facilitating closure of existing facilities.

It is important to note that the sell option is highly dependent on market conditions and external factors such as the availability of technologies to use the uranium. Therefore, any landscape and visual and land use opportunities may not be realised for many years, during which time there would be ongoing environmental impacts associated with continued storage, including repackaging and replacing the stores.

Socio-economic Risks and Opportunities

Whilst storage of the uranium inventory on a continuous basis would prevent the land the stores are built on from being reused, maintenance and repackaging activities support ongoing employment. This includes construction jobs, monitoring and management positions.

Such jobs would be lost under the disposal option, but this could be offset to some extent by operational jobs created to manage a conditioning facility and interim stores. In addition, there would be short-term employment opportunities created during construction of the new facilities.

Under the sell option, jobs involved in managing and maintaining existing stores would be lost when the stores closed, with no new employment created. Depending on the timescales over which the uranium is sold, there may be an opportunity to transfer some of these jobs to other areas of the NDA's operations.

In terms of knowledge and skills, the disposal option may offer opportunities to enhance knowledge and skills in the area of uranium conditioning, which could then be applied to the management of other radioactive materials. The sell option would not directly lead to development of knowledge and skills but may facilitate indirect advances in the area of uranium reuse in fuel.

Health Risks and Opportunities

From a health perspective, under both credible options the Hex inventory would be deconverted in Urenco's purpose-built facility at Capenhurst. This would help to convert the uranium into a more stable and less hazardous form, thereby reducing radiological health risks. In particular, risks associated with cardiovascular and respiratory illness may be reduced, as canisters used to store Hex can leak if they are not actively maintained.

Short-term construction impacts associated with the disposal option, such as changes in air quality and noise and vibration, could have health impacts by slightly increasing the risk of cardiovascular and respiratory illness amongst the local population. Construction traffic may also put pressure on the local transport network which could increase the risk of road accidents and lead to increased driver stress.

Long-term, the disposal option could have some health risks because the long half-life of uranium-238 and the radiological hazard associated with its daughter products have the potential to lead to risks in the very far future. This will be evaluated using a suitable methodology once a disposal site has been determined.

In contrast, selling the uranium inventory may offer health opportunities, as risks associated with the build-up of hazardous daughter products of uranium can be more appropriately managed in the course of treatment prior to fabrication into fuel. It should be noted that these risks are generally very small and dependent on the type of uranium involved. Closure of existing stores may also offer landscape, visual and land use opportunities, which could lead to positive effects on mental health and well-being.

The creation of employment associated with disposal could lead to positive effects on mental health and well-being. The opposite would be true for the sell option, where employment associated with maintaining stores and repackaging the uranium would be lost.

Alternatives

As both of the credible options identified above might be preferred for dealing with a particular group of uranium, there are no other alternative credible options requiring assessment.

5.5 Integrated Waste Management

5.5.1 Radioactive Waste – Higher-activity Waste

Waste management is not a straightforward process of retrieval and disposal. It includes a series of steps: pursuing opportunities for waste minimisation, reuse and recycling, waste processing, packaging, storage, records management, transport and then, where applicable, final disposal.

Following retrieval, radioactive wastes often undergo some form of treatment to make them suitable for disposal. The technologies used to treat the wastes will vary depending on their specific characteristics, the availability of appropriate facilities, time constraints and other relevant factors. Such decisions are made on a case-by-case basis.

The Radioactive Waste strategy is divided into two topics: HAW and LLW. This assessment has focused on the management of HAW. Solid LLW management is covered by the *UK Strategy for the Management of Solid Low Level Waste from the Nuclear Industry* [5], Liquid and Gaseous Discharges are covered by the *UK Strategy for Radioactive Discharges* [6] and non-radioactive waste is managed according to an established, comprehensive and prescriptive regulatory regime.

HAW comprises HLW, ILW and a relatively small volume of LLW that is unsuitable for disposal at the Low-Level Waste Repository in Cumbria or the LLW disposal facility at Dounreay.

From a strategic perspective, the key decisions that need to be made regarding HAW relate to:

1. Where the waste is treated
2. Where the waste is stored (either prior to treatment, following treatment or both)

Strategy (Preferred Option)

The NDA's overarching strategy is to treat and package HAW into a form that can be safely and securely stored for many decades. The current planning assumptions are that, at the appropriate time, the stored waste from England and Wales will be transported to and disposed of in a suitable facility. For HAW arising in Scotland, waste will be managed long-term in near-surface facilities. The NDA HAW strategy supports policy development and implementation.

There are three broad credible options for implementing this strategy: treatment and storage of HAW locally (at or close to the sites where it arises), treatment and storage at regional hubs and treatment at a national facility. Each option may be preferred under certain conditions. Storage of HAW at a national facility is not considered to be credible owing to the number of suitable facilities that already exist across the UK.

Potential Effects

Environmental Risks and Opportunities

From an environmental perspective, the main risks are associated with transport of the wastes to facilities and the footprint of the facilities themselves (including the extent of construction activities involved).

Treatment and storage of wastes locally would involve fewer transport movements than using regional or national facilities. This could provide environmental opportunities in terms of reduced air quality and noise and vibration impacts. Use of regional treatment and storage hubs would likely involve more movements than local facilities but less than the national option.

In terms of the facility footprint, the use of numerous local facilities may involve the greatest material requirements. The regional and national options therefore offer opportunities for achieving economies of scale, which has environmental implications in terms of materials, energy use and carbon emissions.

On the other hand, creation of a single national facility would have the largest physical and environmental footprint. This includes landscape and visual impacts, and may include releases of pollutants to air, water and the ground. Risks of impacts to biodiversity, wildlife and cultural heritage features may also be greater than under the local and regional options, although this is highly dependent on the final location of such a facility.

A degree of packaging and treatment may have to take place prior to transfer of wastes to regional or national facilities. This could result in duplication of effort and associated environmental risks relating to materials and energy. Avoiding these activities would be an environmental opportunity of using local facilities.

Risks from radiological discharges would be managed through the use of extensive controls such as the ALARA principle and BAT and are, therefore, considered unlikely to vary significantly between the options.

Socio-economic Risks and Opportunities

In terms of socio-economic opportunities, the use of local treatment and storage facilities may allow socio-economic benefits such as jobs and investment to be spread amongst a number of communities. In contrast, consolidation of waste at a single national facility could lead to job losses and may require some specialist workers to relocate. It would also mean socio-economic benefits are confined to one particular area.

The main opportunity offered by a single national facility or a number of regional facilities is the freeing up of land at other sites, thereby allowing them to undergo decommissioning and closure. This is less likely to be possible under the local option, meaning that opportunities to reuse the land or divest it for some socio-economic or environmental benefit may not be realised (see Section 5.2.4).

Local facilities may be more complex to design, owing to the need for them to manage a range of different waste types, rather than having a single national or regional facility to manage all wastes of a particular type. This could be seen as an opportunity in terms of advancing knowledge, skills, education and training, or as a risk if it locked-up skills and resources which could be better directed elsewhere. In such a situation, creation of a single specialised facility to manage a particular waste stream may offer socio-economic opportunities, however these would be confined to one location.

Health Risks and Opportunities

One of the main health opportunities offered by the local treatment and storage option is the avoidance of risk associated with transport movements. This includes the risk of traffic accidents and changes in air quality that can influence the risk of cardiovascular and respiratory illness amongst the local population. Treatment at or close to sites may also reduce health risks by ensuring that wastes are converted to a safe and secure form more quickly.

Whilst it is likely that wastes would need to be treated and packaged under the regional and national options to facilitate transport, this could create a logistical challenge which extends the timescale over which wastes are managed. Alternatively, there is a chance that the need to construct multiple local facilities may result in some construction being deferred for funding reasons.

Development of regional or national facilities and subsequent transport of wastes to such facilities may enable decommissioning and remediation to take place at other sites across the estate. This could have positive mental health and well-being effects. On the other hand, loss of or relocation of jobs under a regional or national option could adversely affect the mental health and wellbeing of a local community. This could be seen as a health opportunity under the local option.

Alternatives

As treatment and storage of HAW locally and regionally and treatment of HAW nationally could all be considered preferred options under certain conditions, there are no alternative credible options requiring assessment.

5.6 Cumulative Effects

5.6.1 Types of Cumulative Effect

Cumulative effects are effects which arise from two or more impacts occurring simultaneously where an impact that may not have a significant effect on its own may combine with another to produce a net effect that is significant. There are two main types of cumulative effect relevant to the Strategy. These are:

- **intra-strategy effects**: effects which could result from preferred strategic options being taken forward where the timing of option implementation either overlaps to change the severity of an effect or follows sequentially to prolong an effect; and
- **inter-plan effects**: effects of other strategies, plans or programmes acting in combination with the NDA Strategy.

5.6.2 Intra-strategy Effects

The four driving strategic themes of the Strategy do not operate in isolation at each of the NDA's sites. Instead, all four themes interact with one another and with a fifth theme covering 'Critical Enablers'. The effects of implementing the Strategy may, therefore, change if the preferred options for different themes result in developments or changes in transport or other infrastructure over similar timescales or locations.

For most of the sites in the NDA estate, the two strategic themes with the highest level of interaction, and thus most probability for cumulative effects, are Site Decommissioning and Remediation and Integrated Waste Management. The Spent Fuels and Nuclear Materials themes may also contribute to cumulative effects at some sites.

Interaction Between Site Decommissioning and Remediation and Integrated Waste Management

Successful site clean-up depends on the availability of suitable waste management routes and facilities, and as such, these two themes are inextricably linked. The three credible options for the Decommissioning strategy are decommissioning at pace, decommissioning slowly without interruption and deferred decommissioning (see Section 3.2.1 for descriptions). As stated in Section 3.2.1, decommissioning at a pace could possibly put a strain on existing waste management facilities, as greater volumes of waste may be generated in the short term. As such, decommissioning at pace may not only accelerate the effects identified for the Integrated Waste Management options (see Section 3.5), but potentially increase them, unless new facilities are built or additional capacity is identified. Decommissioning slowly may have a similar effect but allows more time for impacts on waste management facilities to be negated. The extent to which such effects are increased would depend on the number of sites or facilities undergoing continuous decommissioning compared to deferred.

Slow uninterrupted or deferred decommissioning may allow more time to plan appropriate management routes for waste generated, as well as allowing transport movements to be spread out over time. However, there may be a trade-off in terms of extended duration of impacts on land use and the landscape, as the sites will not be remediated as quickly.

The interactions identified above can impact on the time at which sites reach their end states, and therefore the timescales over which environmental, health and socio-economic effects occur (see Section 3.2.3).

As with the Decommissioning strategy, there is a potential interaction between the Land Quality Management strategy and Integrated Waste Management. Depending on the specific conditions of the site and nature of contaminants involved, there is potential for *ex situ* remediation options (which involve excavation) to generate waste materials requiring management under the Integrated Waste Management theme. This may require the provision or expansion of waste management facilities.

Spent Fuels and Nuclear Materials: Additional Cumulative Effects

Management of spent fuels and nuclear materials is an important consideration in the decommissioning and clean-up of a site and also links to the Integrated Waste Management theme. The timing for defueling of sites, for example, may affect decisions on the preferred decommissioning approach, and can also influence Integrated Waste Management and Land Quality Management decisions (e.g. continued operation of facilities can restrict access to areas of contamination or limit space for *in situ* remediation activities to be used).

Magnox fuels are all held at Sellafield. Spent oxide fuels are also mainly held at Sellafield, with additional inventory being transferred to from EDF Energy's seven AGR power stations. Exotic fuels are present mainly at Dounreay and Sellafield.

In terms of nuclear materials, the UK stocks of civil plutonium have now been consolidated at Sellafield. The NDA owns uranium held at Sellafield, Capenhurst and Springfields.

As such, only four of the 17 NDA sites are affected by potential cumulative effects involving Spent Fuel and Nuclear Materials, but seven non-NDA sites, the AGR power stations, could be affected in terms of their future decommissioning programmes. It is not currently envisaged that implementation of any credible option set out in the Strategy would pose a risk to delivery of these contractual commitments.

5.6.3 Inter-plan Effects

The NDA's remit is focused on historical sites, as its mission is to ensure that civil, public-sector nuclear legacy sites are decommissioned safely, securely, cost-effectively and in ways that protect the environment. Other government policies and plans can influence this mission and have implications for how the NDA's Strategy is implemented. These include:

- **The UK Strategy for the Management of Solid Low Level Radioactive Waste in the nuclear industry [5]:** the timing and capacity of LLW management may influence selection and implementation of Site Decommissioning and Remediation and Integrated Waste Management strategies.
- **The Ministry of Defence's Submarine Dismantling Project (SDP):** the reactor cores of disused submarines form ILW, which will be interim-stored at Capenhurst [18].
- **The Department of Energy and Climate Change National Policy Statement for Nuclear Power Generation ('New Nuclear Programme') (NPS EN-6) [19]:** the government has identified the following sites as suitable for the development of new nuclear power stations in England and Wales before the end of 2025. These are Bradwell, Hartlepool, Heysham, Hinkley Point, Oldbury, Sizewell, Sellafield and Wylfa.[7]
- **Advanced Nuclear Technologies:** the UK government recognises that the advanced nuclear sector, which encompasses a wide range of nuclear reactor technologies under development, has the potential to play an important role in the UK's industrial strategy and is funding development work in this area [21]. If advanced nuclear technologies reactors are built in the UK, they may be sited on or close to NDA sites.

For the MoD's SDP, the New Nuclear Programme and advanced nuclear technologies, issues around potential cumulative effects involve the potential for simultaneous construction, intensive decommissioning and remediation activities. These could require more transport capacity than currently anticipated, increase demand for nuclear skills and qualified personnel, or lead to constraints (including scheduling constraints) on options requiring facilities on existing nuclear-licensed sites. The timing of implementation (design, construction and operation) of such developments relative to implementation of the NDA Strategy is uncertain, making it difficult to accurately predict potential cumulative effects. It is crucial that SLCs and the NDA liaise with, and are informed by, relevant parties during future options development and decision-making at the site level.

[7] In 2017, the government held a consultation on the siting criteria and process for a new national policy statement for nuclear power stations with single reactor capacities over 1 GW [20]. The new nuclear National Policy Statement for the period 2026 to 2035 may identify alternative sites within the NDA estate.

5.7 Mitigation

Many of the potential adverse environmental impacts from construction identified in the assessment could be reduced if joint treatment or storage facilities were constructed to manage different types of materials and waste, or if existing facilities are reused wherever possible. Some of the adverse socio-economic impacts associated with closing facilities may be mitigated by transferring staff to alternative facilities or sites.

As there is considerable uncertainty regarding how strategic options will be implemented in future and at the site level, the results of this assessment should be viewed as being indicative of potential impacts of the Strategy, but not absolute or certain. The nature and significance of the identified impacts should be validated in the course of future assessments when more detailed information is available. Such work would enable appropriate mitigation measures to be determined and applied. The results of the IIA should be used to inform this work, as well as future decision-making made by the NDA and the SLCs which operate its sites.

6.0 Conclusion and Next Steps

This IIA aims to inform, but not drive, future NDA strategic decision-making. As such, there are a number of general conclusions that can be drawn from this assessment. These are listed below, along with potential next steps.

6.1.1 General Conclusions

- For most of the Site Decommissioning and Remediation and Integrated Waste Management strategies, the preferred option varies and is selected on a case-by-case basis.
- Development of new and modification of existing facilities will be needed for some of the preferred strategic options. This generally involves a range of major environmental and health risks and socio-economic opportunities.
- Implementation of a number of the preferred options may put pressure on the existing nuclear skills base. This pressure will be increased due to demand from the UK's new nuclear build programme.
- Health risks associated with options are linked to environmental and socio-economic changes.
- Many adverse impacts of construction can be mitigated by reusing existing facilities.
- Some of the adverse socio-economic impacts associated with closing facilities may be mitigated by transferring staff to alternative facilities or sites.
- Adverse environmental impacts from construction could be reduced if joint treatment or storage facilities are constructed to manage different types of materials and wastes. For example, one packaging plant could be constructed to manage spent Magnox, oxide and exotic fuels that are not reprocessed.
- There is considerable uncertainty regarding how options will be implemented in the future and at the site level. The results of this assessment should therefore be viewed as being indicative of potential impacts but not absolute or certain.
- The results of this IIA should be used to inform future, more detailed assessments, to help select strategic options, as well as inform future decision-making made by the NDA and the SLCs which operate its sites.
- Impacts on specific receptors may be more appropriately assessed as part of project-level EIAs.

6.2 Next Steps

- The IIA results will be used as part of the context for future strategic decision-making, alongside other important aspects such as cost, feasibility, security and site-specific factors.
- The assessment methodology will be used in future assessment work.
- Statutory consultees, key stakeholders and the general public will be consulted to obtain feedback on the IIA and identify potential improvements.

Following public consultation, this IIA Report will be published alongside the NDA Strategy (2021). The outcomes of the consultation and its influence on the development of the Strategy and the IIA will be documented in an IIA Post-Adoption Statement.

7.0 References

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