

Geological Disposal: Generic Environmental and Sustainability Report for a Geological Disposal Facility

Assessment Report

October 2010



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Glossary

AGR	Advanced Gas Cooled Reactor – The reactor type used in the UK’s second generation nuclear power plants.
ALARA	As Low As Reasonably Achievable – A term introduced by the International Commission on Radiological Protection, which means that radiological risks to people and the environment should be as low as reasonable achievable, economic and social factors being taken into account.- and certainly below relevant dose limits.
AONB	Area of Outstanding Natural Beauty – Designated under the National Parks and Access to the Countryside Act 1949 to conserve and enhance beauty, including landscape, biodiversity, geodiversity and cultural heritage.
AQMA	Air Quality Management Area – A statutory designation defining an area where air quality is not meeting the national air quality objectives defined by national legislation.
Aquifer	A geological formation that can store and transmit groundwater. Aquifers can be an important source of water for public water supply, agriculture and industry.
Backfill	A material used to fill voids in a geological disposal facility. Three types of backfill are recognised: <ul style="list-style-type: none">- Local backfill, which is emplaced to fill the free space between and around waste packages;- Peripheral backfill, which is emplaced in disposal modules between waste and local backfill, and the near-field rock or access ways; and- Mass backfill, which is the bulk material used to backfill the excavated volume apart from the disposal areas.
BAT	Best Available Techniques/Technology – Those that prevent or minimise pollution, can be implemented effectively and are economically and technically viable, while meeting the overall aims of the EC Directive on Integrated Pollution Prevention and Control (96/61/EC).



Bentonite	A highly sorbing clay material used as a backfill in certain disposal concepts.
BERR	Department for Business, Enterprise and Regulatory Reform (now split between DECC and Department for Business, Innovation and Skills)
BGS	British Geological Survey – A public sector organisation responsible for advising the UK government on all aspects of geoscience as well as providing impartial geological advice to industry, academia and the public.
Boom clay	Boom Clay is a poorly indurated plastic clay of Tertiary age, found in the Mol area of Belgium. The SCK.CEN (Belgian Nuclear Research Centre) began research in 1974 to determine whether radioactive waste could be buried in the Boom Clay formation, and an underground research laboratory named HADES was set up (at a depth of over 200 metres) in the early 80s to study this clay as a potential host formation.
Borehole	The generalised term for any cylindrical excavation into the ground made by a drilling device for purposes such as site investigation, testing and monitoring.
BREEAM	Buildings Research Establishment Environmental Assessment Method – Sets out a method to assess buildings against a range of criteria to determine the environmental impact of a building. Following assessment, an overall score is calculated which may be classed in terms of environmental quality as Pass, Good, Very Good or Excellent.
Buffer	Any substance placed around a waste package in a repository to serve as a barrier to restrict the access of groundwater to the waste package and to reduce by sorption and precipitation the rate of eventual migration of radionuclides from the waste.
Callovo-oxfordian clay	The Callovo-Oxfordian mudrock formation is an indurated Jurassic clay sequence (age approx 150 Ma), located in central eastern France. Andra has undertaken detailed site investigations of the Callovo-Oxfordian clay layer at the Bure site, located in the north east of France.
CHP	Combined Heat and Power – The simultaneous generation of heat and power on a local scale. A CHP system can utilise fossil or renewable fuel sources and can lead to substantial energy savings.



Climate Change	Long-term change in average weather conditions and/or the frequency and nature of extreme weather events. May reflect natural variation and/or variation due to human activity.
CoRWM	Committee on Radioactive Waste Management – An independent body that provides scrutiny and advice to the UK Government on the long-term management of radioactive waste.
CO₂	Carbon Dioxide – A naturally occurring gas and also a by-product of burning fossil fuels and biomass, as well as other industrial processes. It is the most significant greenhouse gas.
DCLG	Department for Communities and Local Government – The successor department to the Office of the Deputy Prime Minister (ODPM). The DCLG sets UK policy on local government, housing, urban regeneration, planning and fire and rescue.
DCMS	Department for Culture, Media and Sport – UK Government department responsible for Government policy on the arts, broadcasting, creative industries, historic environment, licensing and gambling, libraries, museums and galleries, the National Lottery, press freedom and regulation, sport, and tourism.
DCTC	Disposal Canister Transport Container
DECC	Department of Energy and Climate Change (formed from elements of BERR and Defra) – the UK Government department responsible for all aspects of UK energy policy, and for tackling global climate change on behalf of the UK.
Defra	Department for the Environment, Food and Rural Affairs – the UK Government department responsible for policy and regulations on the environment, food and rural affairs.
DoENI	Department of Environment Northern Ireland – The Department of the Environment is one of 11 Northern Ireland Departments created in 1999 by the Northern Ireland Act 1998 and the Departments (Northern Ireland) Order 1999, responsible for land use, air and water quality, waste management and the natural and built environments.
Disposal Canister	Describes HLW/SF/Pu/HEU waste sealed inside a metal container ready for disposal.



Disposal Tunnel	Tunnel in which HLW, SF, Pu and HEU disposal canisters are placed for disposal.
Disposal Vault	Underground opening where ILW or LLW waste packages are emplaced.
Drift	An inclined tunnel, which would provide access to the underground facility.
DTI	Department for Trade and Industry (now the Department for Business, Innovation and Skills).
DU	Depleted Uranium – Uranium with a lower concentration of uranium-235 than occurs naturally in uranium ore. It is a by-product of the uranium enrichment process.
EA	Environment Agency – An Executive non-departmental public body responsible to the Secretary of State for Environment, Food and Rural Affairs and an Assembly Sponsored Public Body responsible to the National Assembly for Wales. The principal aims of the EA are to protect and improve the environment, and to promote sustainable development.
EC	European Commission – The European Union’s (EUs) executive body, which represents and upholds the interests of Europe as a whole and drafts proposals for new European laws. It manages the day-to-day business of implementing EU policies and spending EU funds. The Commission also makes sure that everyone abides by the European treaties and laws.
EIA	Environmental Impact Assessment – A formal, statutory process for identifying the environmental effects (positive and negative) of proposed development projects before development consent is granted. The statutory requirement for Environmental Impact Assessment comes from Directive 85/337/EEC as amended by Directive 97/11/EC and Article 3 of Directive 2003/35/EC. When not strictly required under the terms of the directive and enabling UK legislation, may be undertaken on an informal basis.
Embodied carbon	The carbon emissions associated with embodied energy i.e. the total primary energy consumed during resource extraction, transport, manufacture and fabrication of a product.
EMP	Environmental Management Plan – A plan to monitor and manage the effects of an activity on the environment.



EMS	Environmental Management System – Provides a structured framework through which environmental performance can be monitored, improved and controlled (ISO 14001 is an example of international standard for EMS, to which organisations can become certified).
EU	European Union – An economic and political union of the 27 member states, which are located primarily in Europe.
Evaporite rock	These would typically comprise anhydrite (anhydrous calcium sulphate), halite (rock salt) or other evaporite rocks that result from the evaporation of water from water bodies containing dissolved salts.
Footprint	Indicates the area of host rock required to accept the inventory which is to be disposed of. As well as the inventory for disposal the footprint will be determined by properties of the host rock and the geometry of the features within it. It will also be influenced if disposal tunnels or vaults are able to be built on different levels.
FRA	Flood Risk Assessment – A requirement of PPS 25 (Development and Flood Risk) for England, TAN 15 (Development and Flood Risk) for Wales, SPP 7 (Planning and Flooding) for Scotland and PPS 15 (Planning and Flood Risk) for Northern Ireland. A FRA assesses the risks of all forms of flooding to and from a development, taking climate change into account.
GDF	Geological Disposal Facility – An engineered underground containment facility for disposing of radioactive waste, designed so that natural and man-made barriers work together to minimise the escape of radioactivity.
Geological disposal	Refers to the burial of radioactive waste deep inside a rock formation to ensure that no significant quantities of radioactivity ever reach the surface environment. The term “disposal” implies that there is no intention to retrieve the radioactive waste at some future date.
Geophysical survey	A survey using geophysical methods in order to gain information about the sub-surface. Geophysical techniques include ground penetrating radar (radio), electrical resistivity, seismology and remote sensing.
Geophysical tomography	A technique for investigating subsurface characteristics which produces a 2-dimensional image (slice) of the below ground geological environment.



GVA	Gross Value Added – A measure in economics of the value of goods and services produced in an area or sector of an economy.
HAW	Higher Activity Waste – A term used to describe HLW, ILW and a small fraction of LLW with a concentration of certain specific radionuclides. Also, SF, Pu and U that may be declared as waste in the future.
HEPA filter	High-Efficiency Particulate Air filter – A type of high-efficiency particulate air filter.
HEU	Highly Enriched Uranium – Uranium containing 20% or more of the isotope U-235.
HGV	Heavy Goods Vehicle - A vehicle used for the transport of goods that exceeds 3.5 tonnes.
Higher strength rock	These would typically comprise crystalline igneous and metamorphic rocks or geologically older sedimentary rocks where any fluid movement is predominantly through discontinuities.
HLW	High Level Waste – Radioactive waste above 4 GBq per tonne of alpha or 12 GBq per tonne of beta/gamma activity which releases heat to the extent that it needs to be considered in the design of storage and disposal facilities.
HRA	Habitats Regulations Assessment – Assessment of plans and projects likely to have a significant effect on a European Site as required by Article 6(3) of the Habitats Directive (Convention on the Conservation of European Wildlife and of Wild Fauna and Flora (92/43/EEC)).
HSE	Health and Safety Executive – The national independent watchdog for work-related health, safety and illness.
IAEA	International Atomic Energy Agency – The IAEA is the world's center of cooperation in the nuclear field. It was set up as the world's "Atoms for Peace" organization in 1957 within the United Nations family. The Agency works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies.
ILW	Intermediate Level Waste – Radioactive waste exceeding the upper activity boundaries for LLW (above 4 GBq per tonne of alpha or 12 GBq per tonne of beta/gamma activity), but which does not generate sufficient



levels of heat to require it to be factored into the design of storage and disposal facilities.

LDF	Local Development Framework – Each Local Planning Authority (council) is required to prepare a LDF. This contains the Local Development Documents that set out the spatial planning strategy for a particular area.
LLW	Low Level Waste – Radioactive waste having a radioactive content not exceeding 4 GBq per tonne of alpha activity or 12 GBq per tonne of beta/gamma activity.
LPA	Local Planning Authority – The local authority or council that is empowered by law to exercise planning functions for a particular area of the UK.
Lower strength sedimentary rock	These would typically comprise geologically younger sedimentary rocks where any fluid movement is predominantly through the rock matrix.
MAFF	Ministry of Agriculture, Fisheries and Food (now Defra).
MBGWS	Miscellaneous beta/gamma waste store – ILW storage facility at Sellafield. Waste is stored in MBGWS boxes – unshielded waste containers with an internal volume of 3.5m ³ .
MgO	Magnesium Oxide – Is a chemical compound comprising magnesium and oxygen. Sacks of MgO may be used as buffer material within evaporite rock ILW/LLW disposal vaults.
Minerals sterilisation	Sterilisation of a minerals resource, or a minerals reserve (where a site is covered by valid planning permissions for the extraction of minerals), occurs when other non-minerals development takes place on, or close to, mineral deposits, rendering them incapable of being extracted.
MRWS	Managing Radioactive Waste Safely – The UK Government programme for the long-term management of higher activity radioactive wastes. It is UK Government policy to manage such wastes in the long-term through geological disposal, coupled with safe and secure interim storage and ongoing research and development to support its optimised implementation.



NAEI	National Atmospheric Emissions Inventory – A database of greenhouse gas inventories for England, Scotland, Wales and Northern Ireland, maintained by AEA on behalf of the Department for the Environment, Food and Rural Affairs (Defra) and the Devolved Administrations.
NDA	Nuclear Decommissioning Authority – A non-departmental public body, established under the Energy Act 2004. The NDA is responsible for the decommissioning and clean-up of the UK's civil public sector nuclear sites. The NDA's sponsoring Government department is the Department for Energy and Climate Change (DECC). For some aspects of the NDA's functions in Scotland, the NDA is responsible to Scottish Ministers.
NPPG	National Planning Policy Guidelines – Provide statements of government policy on nationally important land use issues and other planning matters.
NPS	National Policy Statement – Policy statements produced by the Department of Energy and Climate Change (DECC), Department for Transport and the Department for Environment Food and Rural Affairs (Defra). They include the Government's objectives for the development of nationally significant infrastructure in a particular sector and state and include policies or circumstances that Ministers consider should be taken into account in decisions on infrastructure development. NPSs will also become material planning considerations for Local Planning Authorities (LPAs) when determining planning applications.
NO₂	Nitrogen Dioxide – A toxic, reddish-brown gas that is a strong oxidising agent. It is produced by combustion (as of fossil fuels), and is an atmospheric pollutant.
NO_x	Nitrogen Oxide – A gas consisting of one molecule of nitrogen and varying numbers of oxygen molecules. It is present in vehicle exhausts and is an atmospheric pollutant.
NRVB	Nirex Reference Vault Backfill – A specified mix of Portland cement, hydrated lime, limestone flour and water. NRVB may be used for backfilling higher strength rock and lower strength sedimentary rock ILW/LLW vaults.
NuLeAF	Nuclear Legacy Advisory Forum – An organisation set up to represent Local Government at a national level on issues of national nuclear waste management.



ODPM	Office of the Deputy Prime Minister – A central department of Government responsible for policy on housing, planning, devolution, regional and local government and the fire service. It was succeeded in 2006 by the Department for Communities and Local Government (DCLG).
OECD	Organisation for Economic Co-operation and Development – OECD brings together the governments of countries committed to democracy and the market economy from around the world to: support sustainable economic growth, boost employment, raise living standards, maintain financial stability, assist other countries' economic development and contribute to growth in world trade.
ONS	Office for National Statistics – The executive office of the UK Statistics Authority, a non-ministerial department which reports directly to Parliament. ONS is the UK Government's single largest statistical producer.
Opalinus clay	Opalinus Clay is an indurated Jurassic clay (age approx 180 Ma) sequence which, in the Zürcher Weinland area of Switzerland is almost horizontal and laterally continuous over a large area. Nagra has undertaken investigations to assess the suitability of the Opalinus Clay as a host formation for a deep geological repository for HLW, SF and longlived ILW.
PGRC	Phased Geological Repository Concept – The disposal facility concept Nirex developed for ILW/LLW.
PM₁₀	Particulate Matter – Fine particles such as dust, soot and other tiny bits of solid materials that are released into and move around in the air. The number 10 refers to the particle size measured in microns. Particulates are produced by many sources, including construction and mining operations and burning of diesel fuels by vehicles, and is an atmospheric pollutant.
POP	Persistent Organic Pollutants – Organic compounds that are resistant to environmental degradation.
PPE	Personal Protective Equipment – Protective clothing, helmets, goggles, or other garments designed to protect the wearer's body from injury.
PPG	Planning Policy Guidance – Guidance issued by central government setting out its national land use policies for England on different areas of



planning. These are gradually being replaced by Planning Policy Statements (PPS).

- PPS** **Planning Policy Statement** – Statements issued by central Government explaining statutory provisions and providing guidance to local authorities and others on planning policy and the operation of the planning system.
- PSA** **Public Service Agreement** – Agreements detailing the aims and objectives of UK government departments for a three-year period. Such agreements also describe how targets will be achieved and how performance against these targets will be measured. The agreement may consist of a departmental aim, a set of objectives and targets, and details of who is responsible for delivery.
- Pu** **Plutonium** – A radioactive element occurring in very small quantities in uranium ores but mainly produced artificially, including for use in nuclear fuel, by neutron bombardment of uranium.
- PWR** **Pressurised Water Reactor** – A reactor type that uses water under high pressure as a coolant and neutron moderator. PWRs are widely used throughout the world for electricity generation.
- Ramsar Site** A site of international conservation importance designated under the Ramsar Convention (Convention on Wetlands of International Importance) 1971, to protect wetlands that are of international importance.
- RIGS** **Regionally Important Geological Site** – A non-statutory designation for sites of geological or geomorphological importance in a regional / local context. Sites may be designated for educational, cultural, scientific or aesthetic reasons.
- RIM** **Regulatory Interface Management** – the RIM Group is the collective of consultees who the NDA consulted on a proposed approach to sustainability appraisal and environmental assessment for the geological disposal programme. RIM attendees include the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA), the Health and Safety Executive, the Department for Transport, the Department for Communities and Local Government (DCLG), the Planning Inspectorate, and the Local Government Association’s Nuclear Legacy Advisory Forum (NuLeAF).



RSS	Regional Spatial Strategy – A broad development strategy for a UK region covering a fifteen to twenty year period. An RSS informs the preparation of Local Development Documents (LDDs), Local Transport Plans (LTPs) and regional and sub-regional strategies and programmes that have a bearing on land use activities.
RWMD	Radioactive Waste Management Directorate – A Directorate of the UK Nuclear Decommissioning Authority, responsible for a GDF programme.
SA	Sustainability Appraisal – A systematic, iterative and consultative process to appraise the sustainability effects of a strategy, policy, plan or programme. Sustainability appraisal can include the requirements of the Strategic Environmental Assessment Directive.
SAC	Special Area of Conservation – A site designated under the European Community Habitats Directive (92/43/EEC), to protect internationally important natural habitats and species. Part of the Natura 2000 Network.
SAM	Scheduled Ancient Monument – A monument scheduled by the Secretary of State for Culture, Media and Sport protected under the Ancient Monuments and Archaeological Areas Act 1979.
SEA	Strategic Environmental Assessment – A formal, statutory process under the SEA Directive (2001/42/EEC) that incorporates environmental considerations into the development of plans and programmes likely to have significant environmental effects. When not strictly required under the terms of the Directive and enabling UK legislation, SEA may be undertaken on an informal basis.
SED score	Safety and Environment Detriment score – A scoring process used by the Nuclear Decommissioning Authority (NDA) to assess facilities to determine SED reduction projects and scheduling.
SEPA	Scottish Environment Protection Agency – Scotland's environmental regulator. Their main role is to protect the environment and human health and to achieve this by regulating activities that can cause pollution and by monitoring the quality of Scotland's air, land and water.
SF	Spent Fuel – Radioactive fuel assemblies removed from a nuclear power reactor and treated either as radioactive waste or, via reprocessing, as a source of further radioactive materials for creating more fuel.



Shielded waste package	A shielded waste package is one that either has in-built shielding or contains low activity materials, and thus may be handled by conventional techniques. In most cases, shielded waste packages are also designed to qualify as transport packages in their own right.
SNCI	Site of Nature Conservation Interest/Importance – A non-statutory designation for locally important sites of nature conservation interest adopted by local authorities for land-use planning purposes.
SO₂	Sulphur Dioxide – A colourless toxic gas resulting from the combustion of fossil fuels. It is an atmospheric pollutant, reacting with water and oxygen in the air to produce sulphuric and sulphurous acids, which can fall as acid rain.
SPA	Special Protection Area – A site classified under the European Community Directive on Wild Birds (79/409/EEC) to protect internationally important bird species. Part of the Natura 2000 Network.
SSSI	Site of Special Scientific Interest – A statutory designation (under the Wildlife and Countryside Act, 1981) for the best wildlife and geological sites in the country.
SUDS	Sustainable Drainage System – A drainage system designed to minimise the environmental risks resulting from surface water run-off from developments and to contribute wherever possible to environmental enhancement.
SWMP	Site Waste Management Plan – A statutory requirement under the Site Waste Management Plans Regulations 2008, for all new construction projects with a contract value exceeding £300,000. Establishes how construction wastes can be reduced and site-gained materials can be re-used to minimise the amount of waste that has to be disposed of.
SWTC	Standard Waste Transport Container – A re-usable container for radioactive waste packages, used to provide containment and radiation protection to workers and the public during transport and on-site handling operations.
TMP	Traffic Management Plan – Sets out the details of measures to minimise the effects of changes in vehicle movements resulting from a development. It may include routing arrangements and times when delivery vehicles may access the site.



TRU	Transuranic Wastes – long lived ILW.
U	Uranium – A heavy, naturally occurring and weakly radioactive element, commercially extracted from uranium ores. Used as a fuel in nuclear reactors.
UN	United Nations – An international organisation founded in 1945 after the Second World War by 51 countries committed to maintaining international peace and security, developing friendly relations among nations and promoting social progress, better living standards and human rights.
Unshielded waste package	An unshielded waste package is one that, owing either to radiation levels or containment requirements, requires remote handling and must be transported in a reusable transport container (the container and contents then forming a Type B transport package).
Waste Container	A generic term for a vessel used to contain a radioactive wasteform for disposal. It provides a physical barrier in the multi-barrier safety concept (for both ILW and HLW/SF).
Wasteform	Radioactive waste in the physical and chemical form in which it will be disposed of.
Waste Package	Describes a combination of wasteform and waste container.
WIPP	Waste Isolation Pilot Plant – A US Department of Energy facility at Carlsbad, New Mexico for the disposal of defence related trans-uranic radioactive waste.



1. Introduction

1.1 Purpose of this report

This Environmental and Sustainability Report presents the findings of a generic Strategic Environmental Assessment (SEA) undertaken to inform the continuing development of a range of illustrative geological disposal concepts for a co-located geological disposal facility (GDF) for higher activity radioactive wastes (HAW)¹.

The purpose of the assessment is to identify, characterise and assess the likely non-radiological environmental, social and economic effects that may arise at a generic (i.e. non-site-specific) level from implementing different illustrative geological disposal concepts in different geological settings (host rock types). Potential measures that could be used to mitigate adverse, or enhance beneficial, effects have been identified and outlined. These measures could be incorporated into future design iterations for a disposal facility, or taken into consideration during future stages of the process for site selection.

The potential radiological effects of implementing a GDF are being considered as part of a Generic Disposal System Safety Case^[1] which is being developed for the geological disposal programme. The assessments in this report do not seek to duplicate the safety case work. During future stages of the programme, radiological issues would be incorporated into the environmental and socio-economic assessment work.

In completing the generic SEA, it is recognised that it is part of a staged approach to assessment that aims to support the future development of geological disposal concepts to meet regulatory requirements, to comply with accepted best practice, and to provide information to communities that have expressed an interest (or are considering expressing an interest) in participating in the site selection process and in hosting a GDF.

It should be noted that the generic SEA and this report are not part of a formal, statutory assessment process. In consequence, while some aspects of the generic SEA work detailed in this report are in line with the UK SEA Regulations, the work and this report do not seek to be fully compliant with statutory requirements.

A formal, statutory SEA would be undertaken following a community decision to participate in the site selection process. It is anticipated that such an assessment would build on the work in this report, using the potential effects that have been identified and assessed to inform the scope of the work.

¹ Higher activity wastes (HAW) consist of certain Low Level Wastes (LLW) that are not suitable for alternative disposal, Intermediate Level Waste (ILW) and High Level Waste (HLW), and materials not currently declared as waste that may require geological disposal in the future, e.g. Plutonium (Pu), Uranium (U) and Spent Fuel (SF).



Box 1 – Assessment Assumptions and Uncertainties

Some aspects of our generic assessment work are presented quantitatively, in the form of relatively precise figures. However, this precision should not be taken to reflect a high degree of certainty or accuracy. At this very early stage in the geological disposal programme there are inevitably many uncertainties, and as a result we have made many assumptions. As our work progresses more information will become available and in some areas these uncertainties will be resolved.

The quantitative information presented in this report should be seen as illustrative. Figures quoted are often the direct output of design and modelling work based on our current assumptions and are therefore presented with a relatively high level of precision. Working in this way allows us to develop a better understanding of geological disposal and to better focus our future work. A discussion of some of the uncertainties inherent in our current work can be found in **Section 3.6**.

This report is structured as follows:

Section 1 Introduction

This section introduces the purpose of the report, the background to geological disposal and the environmental assessment.

Section 2 Geological disposal concepts

This section provides an overview of illustrative geological disposal concepts for three different geological settings (higher strength rock, lower strength sedimentary rock and evaporite rock), along with associated assumptions and uncertainties.

Section 3 Methodology

This section sets out the approach to the generic SEA and the sustainability objectives used to assess the illustrative geological disposal concepts.

Section 4 The assessment of effects

This section presents the assessment of the illustrative geological disposal concepts against the sustainability objectives, for each phase of their implementation.

Section 5 Conclusions and recommendations

This section provides the conclusions of the assessment, including possible mitigation or enhancement measures and highlights the next steps in the process.

Appendix A Illustrations of geological disposal concepts

This appendix includes illustrations of geological disposal concepts being considered by the Nuclear Decommissioning Authority (NDA).

Appendix B Plans and programmes

This appendix presents a review of international, European, national and regional plans, programmes, strategies and policies considered relevant to geological disposal and which informed the development of the assessment objectives.



Appendix C Baseline evidence

This appendix provides an overview of the baseline information used to inform the assessment of the illustrative geological disposal concepts.

Appendix D Detailed assessment

This appendix provides more detailed information on the illustrative geological disposal concept design requirements for different waste inventories and different host rock types, and information on each of the implementation phases. It also presents the detailed assessment of the illustrative geological disposal concepts for each phase of implementation against the sustainability objectives.

1.2 Background

1.2.1 Managing Radioactive Waste Safely

In 2001 the UK Government and devolved administrations² initiated the Managing Radioactive Waste Safely (MRWS) programme with the aim of finding a practicable solution for the UK's HAW that:

- Achieved long-term protection of people and the environment;
- Did this in an open and transparent way that inspired public confidence;
- Was based on sound science; and
- Ensured the effective use of public monies.

In October 2006, following recommendations made by the independent Committee on Radioactive Waste Management (CoRWM) ^[2] the UK Government and devolved administrations published a response ^[3] accepting CoRWM's recommendations that geological disposal, preceded by safe and secure interim storage, was the best approach for the long-term management of higher activity radioactive wastes.

In June 2008, following an extensive consultation process, the Government published a White Paper setting out a framework for implementing geological disposal ^[4].

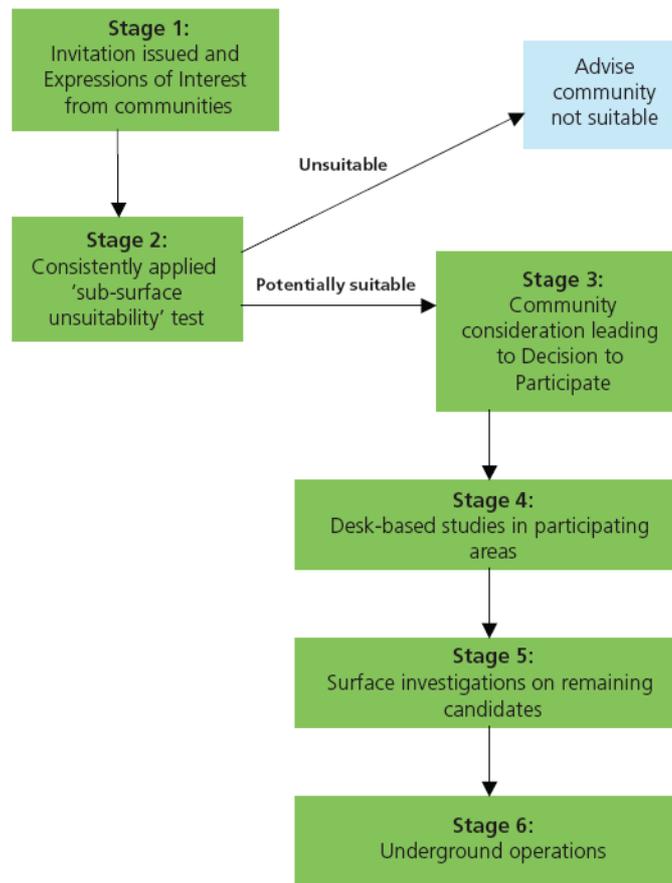
² UK Government in this context means the Department for Environment, Food and Rural Affairs (Defra) and the Department for Business, Enterprise and Regulatory Reform (BERR). Some elements of Defra and BERR have been brought together in the Department of Energy and Climate Change (DECC). The Devolved Administrations are the Welsh Assembly Government and the Department of the Environment Northern Ireland. The Scottish Government supports long-term near surface, near site storage and disposal facilities for higher activity radioactive wastes and therefore did not sponsor the MRWS White Paper.



1.2.2 The Managing Radioactive Waste Safely site selection process

The MRWS White Paper^[4] sets out a six stage approach for selecting a site and implementing a GDF (**Figure 1.1**). The UK Government is using a voluntarism and partnership approach to implement geological disposal. This is an approach in which communities voluntarily express an interest in taking part in the site selection process that will ultimately provide a site(s) for geological disposal.

Figure 1.1 Managing Radioactive Waste Safely site selection process



Source: MRWS White Paper^[4]

1.2.3 The Nuclear Decommissioning Authority's role in the site selection process

The NDA is a non-departmental public body that was established under the Energy Act 2004^[5] with responsibility for the decommissioning and clean-up of the UK's civil public sector nuclear sites. The MRWS White Paper^[4] identifies the NDA as the implementing organisation responsible for planning and delivering a GDF. The NDA has



set up the Radioactive Waste Management Directorate (RWMD) to develop an effective delivery organisation to implement a safe, sustainable and publicly acceptable geological disposal programme³.

During the current Stages 1, 2 and 3 shown in **Figure 1.1**, the NDA is supporting the UK Government and local communities as they consider expressing an interest and taking a decision to participate in the site selection process. The NDA is also developing geological disposal concepts that could be suitable for the UK and is assessing their potential effects should they be implemented.

Participating communities whose areas have not been screened out by subsurface criteria and who wish to continue their involvement will be carried forward to Stage 4. The UK Government would then ask the NDA to undertake further desk based investigations in these communities to evaluate their potential suitability for hosting a GDF and to assess the potential impacts of building a GDF in the area.

At the end of Stage 4 there would be a staged decision making process as outlined in the MRWS White Paper^[4]:

- A Community Siting Partnership⁴ would make recommendations to local Decision Making Bodies⁵ about whether to proceed to the next stage of the site selection process.
- Decision Making Bodies would decide whether to proceed to the next stage of the site selection process.
- The Government would then decide on one or more candidate site(s) to take forward to Stage 5.

During Stage 5 of the site selection process the NDA would undertake more detailed studies and assessments of the remaining candidate sites. These would involve surface-based site investigations which would include boreholes and regional surveys.

³ It is envisaged that this Directorate will become a wholly owned subsidiary company of the NDA. Ultimately, it will evolve under the NDA into the organisation responsible for the delivery of a GDF. Ownership of this organisation could then be opened up to competition, in due course, in line with other NDA sites.

⁴ Government expects communities who decide to participate in the site selection process to establish a Community Siting Partnership that would include all local interests, working together to achieve a successful outcome. The NDA's delivery organisation would be a member of the Partnership but would not be directly involved in decisions on community related issues.

⁵ Local Government will have decision-making authority for their host community. There are different local authority structures in different parts of the UK. For example, in England local authorities include district councils, county councils, metropolitan district councils and London boroughs, whereas in Wales local authorities are unitary. In the MRWS White Paper Government calls such a body a 'Decision Making Body'.



The decision making process at the end of Stage 5 would be:

- A Community Siting Partnership would make recommendations to its local Decision Making Bodies about whether to proceed to the next stage of the site selection process.
- Decision Making Bodies would decide whether they wished to proceed to the next stage of the site selection process.
- Government would make an informed decision on a preferred site.

The NDA would then apply for planning permission to implement a GDF at the preferred site.

The NDA is working with regulators, Government and planning authorities on the development of a Permissions Schedule for the implementation of geological disposal showing the various regulatory permissions that will be needed within the stages of the Government's MRWS site selection process. The NDA's Permissions Schedule ^[6] sets out how obtaining land-use planning permissions (and the environmental assessments that support them) can be co-ordinated with the permissioning processes for a nuclear site licence, authorisation for the disposal of radioactive waste, and the many other permissions that would be needed for the successful implementation of geological disposal.

1.2.4 Illustrative geological disposal concepts

There is a range of geological environments in the UK that could be suitable for constructing a GDF. There is also a range of geological disposal concepts, being studied and developed in the UK and internationally, that could provide safe and secure geological disposal of HAW within this range of geological settings. At this stage the NDA is examining a wide range of potentially suitable geological disposal concepts so that a well informed assessment of options can be carried out at appropriate decision points in the implementation programme. Drawing from this work, illustrative geological disposal concepts for each of three generic geological settings are being developed and used to:

- Further develop understanding of the functional and technical requirements of the disposal system;
- Further develop understanding of the design requirements;
- Support the scoping and assessment of the safety, environmental, social and economic impacts of a GDF;
- Support development and prioritisation of the NDA's research and development programme;
- Underpin analysis of the potential cost of geological disposal; and
- Support assessment of the disposability of waste packages proposed by waste owners.



The NDA is developing illustrative geological disposal concepts solely for these purposes. It is not intended that one of these geological disposal concepts is necessarily going to be implemented. At this stage, no geological disposal concept has been ruled out.

The illustrative geological disposal concepts are listed in **Table 1.1** and illustrations of these concepts are provided in **Appendix A**.

Table 1.1 Illustrative geological disposal concepts

Host rock	Illustrative Geological Disposal Concept Examples ^d	
	ILW/LLW	HLW/SF
Higher strength rocks ^a	UK ILW/LLW Concept (NDA, UK)	KBS-3V Concept (SKB, Sweden)
Lower strength sedimentary rock ^b	Opalinus Clay Concept (Nagra, Switzerland)	Opalinus Clay Concept (Nagra, Switzerland)
Evaporites ^c	WIPP Bedded Salt Concept (US-DOE, USA)	Salt Dome Concept (DBE-Technology, Germany)

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Notes:

- a Higher strength rocks – the UK ILW/LLW concept and KBS-3V concept for SF were selected due to availability of information on these concepts for the UK context.
- b Lower strength sedimentary rocks – the Opalinus Clay concept for disposal of long-lived ILW, HLW and SF was selected because a recent Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency review^[7] regarded the Nagra (Switzerland) assessment of the concept as state of the art with respect to the level of knowledge available. However, it should be noted that there is similarly extensive information available for a concept that has been developed for implementation in Callovo-Oxfordian Clay by Andra (France), and which has also been accorded strong endorsement from international peer review. Although the Opalinus Clay concept will be used as the basis of the illustrative example, the NDA will also draw on information from the Andra programme. In addition, the NDA will draw on information from the Belgian super container concept, based on disposal of HLW and SF in Boom Clay.
- c Evaporite rock – the concept for the disposal of transuranic wastes (TRU) (long-lived ILW) in a bedded salt host rock at the Waste Isolation Pilot Plant (WIPP) in New Mexico, USA was selected because of the wealth of information available from this certified, and operating facility. The concept for disposal of



HLW and SF in a salt dome host rock developed by DBE Technology (Germany) was selected due to the level of concept information available.

- d For planning purposes the illustrative concept for depleted, natural and low enriched U is assumed to be same as for ILW/LLW, and for Pu, and Highly Enriched Uranium (HEU) is assumed to the same as for HLW/SF.

Illustrative geological disposal concepts are being developed as “co-located” facilities for LLW, ILW and HLW, and other radioactive materials (Pu, U and SF) that may be declared as a waste in the future. In a co-located facility there would be two distinct excavated disposal areas, separated by an appropriate distance, one for ILW, LLW and U residues, and the other for HLW, SF, Pu and HEU. This is in line with the statement made in paragraph 4.25 of the MRWS White Paper which states that “*in principle the UK Government sees no case for having separate facilities if one facility can be developed to provide suitable, safe containment*”. However, as stated in the White Paper, “*the final decision would be made in the light of the latest technical and scientific information, international best practice and site-specific environmental, social, economic and safety and security assessments*”, so the possibility that more than one facility would be needed is recognised.

The NDA has produced a draft report entitled ‘*Geological Disposal – Generic disposal facility designs*’, which details illustrative geological disposal concepts for each generic host rock type^[8]. The report identifies GDF design requirements for three different radioactive waste inventories: the Derived Inventory Reference Case; the Derived Inventory Reference Case excluding Pu/U; and the Derived Inventory Upper Inventory. These waste inventories have been derived from radioactive waste stream data in the Baseline Inventory⁶, as detailed in the MRWS White Paper^[4] and the 2007 UK Radioactive Waste Inventory^[9], to provide waste package volumes to inform GDF design requirements. The Derived Inventories for geological disposal concepts have also improved on the information in the 2007 UK Radioactive Waste Inventory by addressing gaps and data anomalies. They comprise of the following waste streams:

- Derived Inventory Reference Case – this includes ILW/LLW, HLW/SF and Pu/U as consistent with the Baseline Inventory;
- Derived Inventory Reference Case excluding Pu and U;
- Derived Inventory Upper Inventory - ILW/LLW, HLW/SF, Pu/U including uncertainties and potential additional wastes⁷.

⁶ The UK Baseline Inventory was based on information from the 2007 UK Radioactive Waste Inventory. This provides a national record of information on radioactive wastes in the UK, including civil nuclear materials such as Pu, U and SF.

⁷ Potential variations in the UK Baseline Inventory due to uncertainty in the declared radionuclide inventories; potential variations in the UK Baseline Inventory due to changes in the key assumptions for future waste a risings in the 2007 UK Radioactive Waste Inventory; materials that are not currently included in the 2007 UK Radioactive Materials Inventory and hence not included in the UK Baseline Inventory (such as Ministry of Defence fuels) but may require geological disposal; and,



RWMD have also undertaken preparatory work in relation to the implementation of site investigations which is detailed in a number of published reports ^{[26] [27] [28] [29] [30]}.

For the purposes of the assessment it is assumed that any of these geological disposal concepts would be implemented in four phases:

- **Surface-based site investigations:** A range of detailed surface-based site investigations would be undertaken to gather information on the environment. This information would assist with the selection of a suitable site and design. The activities associated with this phase include a series of drilling campaigns resulting in approximately 20 deep (>1,000m) boreholes from 14 - 16 drilling platforms and an additional 50 shallow (<100m) boreholes. Investigations would commence in Stage 5 of the MRWS site selection process and would last for approximately 10 years.
- **Construction:** Following completion of the surface-based site investigations and public endorsement of a preferred location and design, it is assumed that the construction of a GDF would begin. A GDF would consist of surface buildings and infrastructure, an access road, rail infrastructure, underground accesses (a drift and/or several shafts) and waste disposal areas (ILW/LLW vaults and HLW/SF disposal tunnels) and underground service area, connected by a network of underground roads. Initial construction would take around 10 years, during which time the underground accesses would be constructed as well as the first ILW/LLW vaults.
- **Operation:** Following initial construction, a GDF would enter the operational phase. The key activities during operation would be the ongoing construction of the ILW/LLW vaults and HLW/SF disposal tunnels as required, the emplacement of the radioactive waste into the waste disposal areas, and the backfilling of the waste disposal areas. Depending on the host rock type, some waste disposal areas would be backfilled when full of waste, and some would remain open until all of the waste was emplaced within the facility. The emplacement of radioactive waste is assumed to begin in 2040 and potentially continue until 2128.
- **Closure and post-closure:** Following the completion of waste emplacement, a GDF would be closed over a period of 10 years with the remaining underground facilities backfilled and sealed and the surface facilities and infrastructure decommissioned. During this time the environmental conditions and structural integrity of a GDF would be monitored. The site would then be restored to an agreed end state.

Further information on the illustrative geological facility concept designs for each of the host rock types and the different waste inventories considered in this assessment is provided in **Section 2**.

A range of transport modes and combinations of those modes are being considered by the NDA to transport the materials required to construct a GDF and transport radioactive waste for geological disposal, including rail, road and sea. Transport associated with a GDF would comprise four components:

wastes from potential new build nuclear power stations. A programme of nuclear build sufficient to maintain current nuclear generating capacity has been assumed.



- Movements associated with the transport of radioactive waste from the locations where the waste arises to a GDF;
- Movements of materials and personnel associated with the construction of a GDF, including construction of new or enhanced transport facilities at the site;
- Movements associated with the operation of a GDF (e.g. personnel);
- Movements of (non-radioactive) waste arising at a GDF site to appropriate management/disposal facilities.

For the purposes of this assessment, for all host rock types two transport scenarios for the transport of radioactive wastes have been considered; ‘RoadRail’ and ‘SeaRoadRail’. For the RoadRail scenario, it is assumed that 70% of the radioactive waste would be transported to a site by rail, with the remaining 30% transported by road⁸. For the SeaRoadRail scenario, it is assumed that 80% of the radioactive waste would be transported to a site via ship, with the remaining 10% by road and 10% by rail from the port to the site⁹.

Further information on the proposed transport scenarios and assumptions made in this assessment is provided in **Section 2**.

1.3 Strategic Environmental Assessment

SEA became a statutory requirement following the adoption of the European Union’s Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment^[10]. This 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 objective of the SEA Directive is:

“to provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to contributing to sustainable development.”

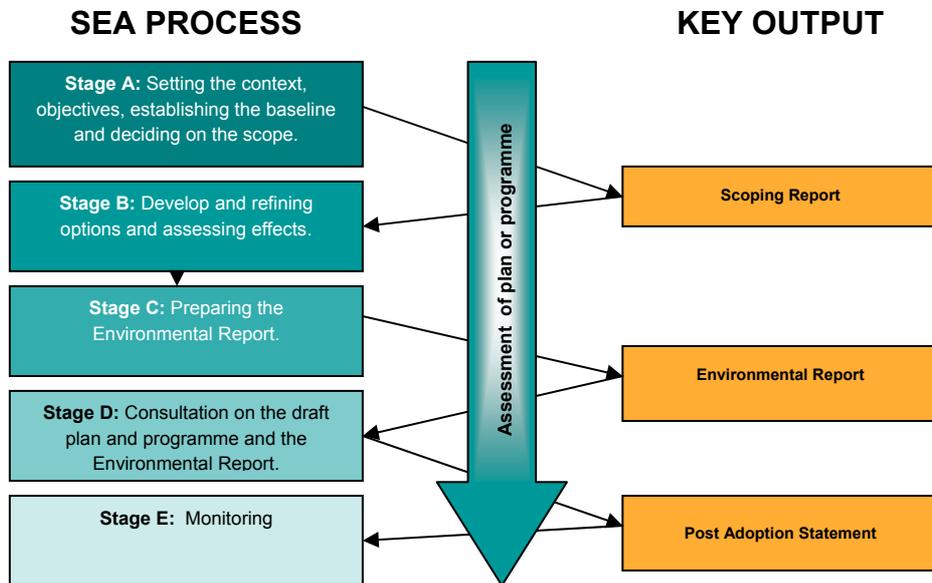
Throughout the course of the development of a plan or programme, the aim of the SEA is to identify the associated environmental effects of implementing the plan or programme, to propose measures to avoid, manage or mitigate any significant adverse effects and to enhance any beneficial effects.

⁸ For the RoadRail scenario, packages that have a mass less than the limits for HGV transport are moved by road. Heavier packages are transported by rail from the nearest railhead.

⁹ For the SeaRoadRail scenario, packages are transported by sea for the major part of the route with road or rail transport to the dispatch port depending on the mass of the package and the availability of an on-site railhead. The journey from the receipt port to a GDF is assumed to be by rail.



Figure 1.2 Outline of the Strategic Environmental Assessment process



Source: Entec (2010)

The main stages of the SEA process (as shown in **Figure 1.2**), are:

- **Stage A** – The scope of the assessment is determined and the proposed approach agreed with statutory consultees.
- **Stage B** – The likely environmental effects of the proposals and reasonable alternatives are assessed.
- **Stage C** – An Environmental Report is written detailing the results of the assessments.
- **Stage D** – Public consultation on the plan or programme proposals and on the Environmental Report, with the findings integrated into the final decisions on how to proceed with the proposed plan or programme. The public are informed on the decision and the extent to which the SEA and consultation findings have been taken into account.
- **Stage E** – The environmental, social and economic impacts of the adopted plan or programme are monitored.

The MRWS White Paper ^[4] requires the NDA to develop a strategy for sustainability appraisal and environmental assessment for the implementation of a GDF. The MRWS White Paper states that:

“Government is committed to ensuring that the NDA’s geological disposal facility programme fully assesses and accounts for environmental impact and sustainability issues through the application of [Strategic Environmental Assessment] SEA, [Sustainability Appraisal] SA and [Environmental Impact Assessment] EIA. The Government expects the NDA to undertake sustainability appraisal, meeting the



requirements of the SEA Directive. The Government and the NDA will undertake work on the scope of that sustainability appraisal following publication of the White Paper. There will be close co-ordination and integration of this work and it will continue after candidate communities have been identified to enable local issues and views to be integrated into the sustainability appraisal.

Following the publication of this White Paper, the NDA will prepare and publish for consultation its proposals for sustainability appraisal and environmental assessment.”

The NDA consulted on a proposed approach to sustainability appraisal and environmental assessment for the geological disposal programme between August and November 2008. To facilitate the consultation, the NDA developed a consultation document ‘*NDA consultation on a framework for sustainability appraisal and environmental assessment for geological disposal*’^[11]. The NDA held meetings with the Department of Communities and Local Government (DCLG), Defra, BERR and the Regulatory Interface Management (RIM) Group¹⁰ when putting the consultation document together. The responses to the consultation document have been analysed and summarised^[12]. A workshop was held in October 2008^[13] to enable stakeholders to discuss the consultation.

The responses to the consultation and the outcome of the workshop were taken into account in developing the ‘*Strategy for Sustainability Appraisal and Environmental Assessment*’^[14]. The Strategy states that the approach should meet the requirements of the SEA Directive^[12] and transposing regulations, that the assessment should be called an SEA and should cover environmental, social and economic considerations. Finally, the Strategy proposes that the ‘*Environmental Report*’ required by the SEA Directive should be called an ‘*Environmental and Sustainability Report*’.

The Strategy also states that the results of the assessment should be used, alongside assessments of likely health, safety and security impacts, to inform:

- Local decisions about whether to participate in the next stage of the site selection process;
- National decisions about which candidate communities and then candidate site(s) should proceed to the next stage of the site selection process;
- Work streams aimed at obtaining regulatory permissions such as authorisation to dispose of radioactive waste; and
- Subsequent EIA work supporting planning permission applications.

¹⁰ RIM attendees include the Environment Agency (EA), the Scottish Environmental Protection Agency (SEPA), the Health and Safety Executive, the Department for Transport, DCLG, the Planning Inspectorate, and the Local Government Association’s Nuclear Legacy Advisory Forum (NuLeAF).



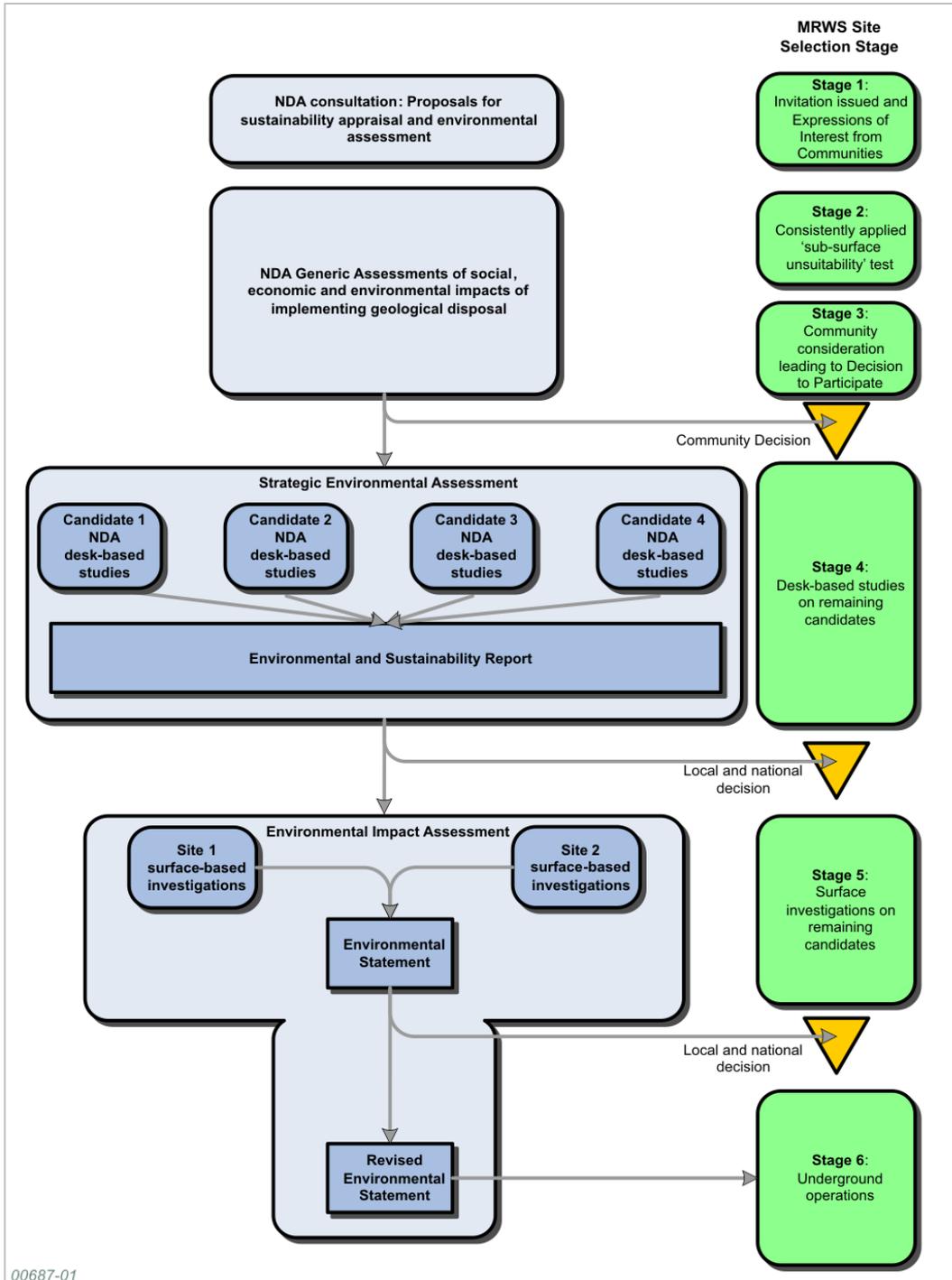
The Strategy proposes that the aims of the SEA should be:

- To promote a sustainable outcome for the geological disposal programme;
- To identify the potential environmental, social and economic effects of the NDA's proposals for geological disposal;
- To provide information that will assist in developing the proposals and the design of a disposal facility to address the effects identified;
- To put in place measures to prevent, design out or mitigate adverse impacts, maximise positive impacts and monitor the effect of the NDA's plans and programmes for geological disposal;
- To establish the environmental, social and economic baseline in areas being investigated to enable prediction of effects and subsequent monitoring; and
- To set out the findings of the SEA process and provide this information to stakeholders to inform decision making and build public confidence.

The relationship between the environmental (and socio-economic) assessment process and the site selection process is outlined in **Figure 1.3**.



Figure 1.3 Overview of Managing Radioactive Waste Safely assessments



Source: NDA ^[12]



In accordance with the Strategy, the NDA is proposing to undertake the following assessments:

- **A Generic (i.e. not site-specific) SEA** of a range of illustrative disposal facility concepts during Stages 1 to 3 of the MRWS site selection process (the subject of this report). This assessment will help to identify the potential environmental, social and economic impacts of implementing a GDF and will be used to influence the development of geological disposal concepts. It is recognised that communities may want information on the potential environmental, social and economic impacts to inform their decision to participate during Stage 3 of the MRWS programme and that the assessments could be used to help them develop their understanding of the potential impacts of hosting a GDF. As noted in **Section 1.1**, this assessment does not form part of a formal, statutory process as defined in UK SEA Regulations.
- **An SEA of the NDA's proposals for how a GDF would be implemented in each candidate community**, including the proposals for surface-based investigations in each of those communities. These assessments would be undertaken during Stage 4 of the MRWS site selection process and would be strategic in nature because a specific site(s) may not have been identified and the assessments would be based on desk based studies. However, the assessment would include information about the candidate communities being considered and therefore may focus on a number of discrete areas or sites. Purely for planning purposes we have assumed that the SEA would consider four such areas or sites. The assessments would be developed iteratively as the desk based studies progress and the results would be fed into the development of the NDA's proposals for implementing geological disposal. These assessments would be used in local and national decisions about which site(s) to investigate in Stage 5 of the site selection process. The SEA undertaken at this stage would be fully compliant with the UK SEA Regulations.
- **EIAs of proposals for undertaking intrusive surface investigations and/or construction work** associated with the site investigation programme at specific candidate site(s). These assessments would be undertaken during Stage 5 of the MRWS site selection process and would support any planning applications that were needed. For planning purposes, we have assumed that two of the four candidate sites would be carried forward from Stage 4 for more detailed study during Stage 5.
- **An EIA of the proposed design and implementation of a GDF in each of the candidate site(s)** being considered during the site selection process. These assessments would be undertaken during Stage 5 of the MRWS site selection process and would assess a specific disposal facility design(s) for the candidate site(s) being proposed. The assessments would be developed iteratively as the surface-based investigations progress and the results would be fed into the development of the disposal facility design(s). These assessments would be used in local and national decisions about the preferred site and disposal facility design.
- **An EIA of the preferred design and preferred site** as an input to the planning application for the implementation of a disposal facility. This assessment would be undertaken during Stage 6 of the MRWS site selection process and would be a revision of the assessment undertaken in Stage 5.

The EIAs would build on the SEA work that preceded them. The information gathered for the SEA would be an important input to the EIAs, although the EIAs would evaluate potential impacts in more detail than the SEA and additional information would have to be obtained to enable a more detailed assessment.



The SEAs and EIAs would be developed iteratively with design development for a GDF. The results of the assessments would be fed into the development of the designs to enable any adverse environmental, social and economic impacts to be designed out or mitigated where possible.

1.3.1 Assessment work to date

Previous assessment work facilitated the early identification of potential sustainability effects of a GDF and has resulted in a number of outputs that this assessment has considered and built on. These are the:

- Non-radiological Environmental Assessment of the Nirex Phased Disposal Concept – Generic Concept Design Assessment Scoping Report ^[15];
- Non-radiological Environmental Assessment of Intermediate Level Waste and Low Level Waste Phased Geological Repository Concept (PGRC) ^[16];
- Sustainability Appraisal of the Reference High Level Waste and Spent Fuel Concept Assessment Report ^[17]; and
- Sustainability Appraisal of the Surface-based Investigations for the PGRC ^[18].

The following sections summarise the previous assessment work undertaken and the key issues identified.

Non-radiological assessment of Intermediate Level Waste and Low Level Waste concept

In 2007, the non-radiological environmental assessment of the PGRC commenced with the publication of a Scoping Report for the generic concept design ^[15]. The Scoping Report broadly identified the assessment criteria and methodology for assessments over three distinct stages, based on a staged decision-making process and the level of detail that would be known about the potential sites:

- Stage 1 assessments, which would be broadly generic, non-site-specific and focus on the strategic effects.
- Stage 2 assessments, which would provide a more detailed level of information regarding the siting options.
- Stage 3 assessments, which would focus on the detailed effects arising at a particular site and result in an EIA being undertaken.

In 2007, RPS produced a Characterisation Report ^[19] which described the key stages of the PGRC and set out the key assumptions in terms of the disposal facility design and likely activities associated with it in order to form the basis for the Stage 1 environmental assessment of geological disposal concepts ^[16].

Initial work was undertaken relating to the generic concept design of a geological facility for ILW and certain LLW. This concept highlighted the use of a multi-barrier containment approach for the emplacement of ILW and



LLW in an underground disposal facility. Initial transport scenarios were considered for maximum road usage and road/rail (where all waste packages that can be transport by Heavy Goods Vehicle (HGV) are, whilst those that cannot are moved by rail).

The assessment approach was based on that set out in the Scoping Report ^[15]. This highlights a list of factors (indicators) for each topic to be considered at each stage of environmental assessment. As specific sites were not identified, the Stage 1 assessment report provided a generic assessment. The assessment approach made use of the Characterisation Report ^[19] to identify what activities would occur at each stage of the project and what potential effects may arise.

The resulting Stage 1 generic environmental assessment identified a number of non-radiological effects. These are summarised in **Table 1.2**.

Table 1.2 Summary of effects of a disposal facility for ILW and LLW

Objective	Summary of effects of a disposal facility for ILW and LLW
<p>Landscape and Visual</p>	<p>The scale of the scheme, particularly during construction could result in elements of the site being visible over a considerable distance. The most significant effects are anticipated during the construction phase, due to the leveling of the site and change in character resulting from the introduction of new infrastructure such as lighting, access roads and buildings. In particular, the tallest elements on site are likely to be the headframes associated with the shafts. These would appear as solid structures approximately 35m tall and would be visible over considerable distances. Screening mounds around the site would be provided and formed from the spoil generated during subsurface vault excavation, which may have visual effects. It is noted that the operational stage will begin before the construction phases are completed for the whole site.</p> <p>Closure of the site may result in positive or negative effects depending on the nature of site restoration and the nature of the landscape context at the time of site closure.</p>
<p>Cultural Heritage</p>	<p>Potential effects that may arise at the site during construction and operation, or as a result of associated transport infrastructure, include the direct loss or damage to visible historic or archaeological features. Similarly, the facility may affect the setting and amenity of visible historic or archaeological features. Excavation activities during construction may lead to a direct loss of, or damage to, subsurface archaeological remains that may be previously known or unknown. Indirectly, changes to the hydrological regime or contamination to the ground may affect subsurface assets. The introduction of surface infrastructure, such as access roads and waste receiving buildings may also have effects on the historic landscape.</p> <p>Effects on designated sites would depend on the location of the facility and such effects should be considered during the site selection process.</p>
<p>Geology and Soils</p>	<p>There will be significant excavation of materials from the site (which may contribute to important national mineral resources or may form part of sites of recognised importance, e.g. Sites of Special Scientific Interest (SSSI) or Regionally Important Geological Sites (RIGS). There would be a loss of some 144ha of topsoil, which could be of a high agricultural grade (as the facility is assumed to be located in a greenfield site).</p>



Objective	Summary of effects of a disposal facility for ILW and LLW
Water Resources	<p>The magnitude of the effects arising at the construction site is potentially high given the scale of the development. However, this would be reduced by the identification of a suitable facility location through the extensive site investigation proposed and the implementation of reasonable measures to control the rate of runoff, the careful identification of water sources for use on site and the provisions made in the design for treatment and analysis of discharged water.</p> <p>During operation, the key additional effect would be drainage from the filled vaults. This would be controlled through the implementation of the proposed effluent treatment and analysis measures and through the established system in place for consent of discharges by the relevant agency.</p> <p>Indeed, the design would include a drainage effluent treatment facility, whilst surface runoff would be collected separately from other waste streams and its constituents analysed. This runoff would only be mixed with other streams of liquid effluent if radiologically and chemically justifiable.</p>
Ecology and Nature Conservation	<p>Disturbance to the condition of areas and/or habitats of nature conservation value during site characterisation, construction, operation, and closure stages of the facility, or from the transport of waste from waste-producing sites to the facility. This may arise in the form of changes in air quality, light pollution, or dust deposition, or hydrological changes affecting either surface or ground waters.</p> <p>Disturbance to the effects on species of nature conservation value. This may result from the changes in conditions of habitats, changes in noise, vibration or water quality, habitat fragmentation and the changes in the number of predators and/or prey.</p> <p>Effects on ecology and nature conservation may include wildlife mortality during the site characterisation, construction, operation and closure of the facility, or due to the transport of waste, as a result of collisions with traffic or the possible release of pollutants.</p> <p>Furthermore, there may be a loss of habitats or habitat fragmentation as a result of the introduction of new surface facilities during construction and operation. However, habitat creation or enhancement may be provided as part of the proposed development on the site, for example creation of large mounds of spoil.</p>
Traffic and Transport	<p>The facility would require infrastructure to support the delivery of waste packages, potentially by road or rail. One or a small number of preferred road routes would be identified for HGVs from the national motorway and trunk road network. These would be routes that offer the best available combination of safety, ease of access and low environmental effect.</p> <p>The design shall not preclude the use of either rail or road as a means for transport of construction materials or any combination of transport modes. Particular consideration would be given to the use of rail transport for bulk materials. Depending on the availability of public transport, a significant proportion of personnel may travel by public transport and consideration would be given to the bussing or transport by train of construction personnel.</p> <p>There are expected to be between 15 and 16.5 arrivals per week for the Reference or Variant Case respectively, from waste transport. This compares with an estimated 70 HGV arrivals per week during the construction phase, 20 HGV arrivals per week during operation/construction phase, 10 HGV arrivals per week during the care and maintenance phase and 400 HGV arrivals during the backfilling phase. Waste transport is anticipated to account for between 0.4 million network km and 1.2 million network km per year depending on the location of the facility. The maximum number of trains associated with the waste transport equates to some 4 trains per week. This would be negligible in terms of the effect on the existing rail network.</p>
Air Quality and Climate	<p>There may be temporary dust effects from construction if unmanaged. There may be effects on air quality from vehicle movements particularly during peak activities on sites. Modelling data has highlighted that for the Reference Case scenario, total emissions from waste transport could vary from 356,000 tonnes to over 950,000 tonnes of Carbon Dioxide (CO₂). During the operation of the facility, an additional consideration would be the venting of gases and any associated odour. Should potentially significant emissions be identified from discharge stacks in subsequent stages of assessment, dispersion modelling should be undertaken to indicate ground level pollutant concentrations and inform design stack height and configuration.</p>



Objective	Summary of effects of a disposal facility for ILW and LLW
Noise and Vibration	There are likely to be a number of activities which will result in perceptible changes in noise. Effects would be more perceptible at night time further from the facility than during the day. It is assumed that the closest sensitive receptors to the sites are likely to be rights of way of public open space. In the absence of mitigation, effects may be observed at receptors up to 2.8 km away at night time during the initial construction phase. Whilst mitigation measures may help reduce the effects of noise, the significance of noise levels is dependent on the local setting. The effects of vibration are likely to be limited to acceptable levels through the implementation of appropriate mitigation measures, although it is uncertain whether this addresses vibrations from rock blasting.
Socio-economics and Land Use	There is anticipated to be a significant positive effect from the creation of a number of jobs, up to 370 for 9 years and up to 500 for 50 years, during construction and operation. It is recognised that the indirect effects on employment would spread over a large area and may extend regionally, nationally or internationally. There could be a permanent loss of between 93 and 144 ha, with greatest land use effects occurring during construction.
Health and Safety	A number of potential hazards were identified as issues that may arise, particularly during construction and operational activities including electrical hazards causing a fire, structural instability, exposure to hazardous substances and loss of ventilation.
Resource Use, Utilities and Services	There is likely to be a substantial increase in the use of energy and other resources, particularly during construction.

Sustainability appraisal of High Level Waste and Spent Fuel concept

Following the assessment work on the PGRC for ILW and LLW, the UK Reference HLW and SF concept was subjected to a Sustainability Appraisal ^[17] with the aim of highlighting any significant effects that may occur at the generic level. A Characterisation Report was produced setting out a description of a facility concept for HLW and SF ^[20]. As with the PGRC for ILW and LLW, it was assumed that a multi-barrier containment approach was to be adopted with HLW and SF being emplaced in an underground facility. The UK Reference HLW and SF concept was based around five stages of implementation, from desk based studies through to site closure and post-closure activities.

The non-radiological sustainability appraisal considered the effect the UK Reference HLW and SF concept would have towards achieving a number of sustainability objectives. Indicators were developed by which the performance against each objective was measured. Effects against some objectives such as cultural heritage and ecology were considered to be site-specific to the extent that no meaningful assessment could be undertaken, although the report indicated how they could be assessed in the future.

The effects identified in the assessment were very similar to those identified for the PGRC for ILW and certain LLW. This is due to the fact that the disposal facility design remained broadly similar, with only the waste for emplacement, emplacement methodology and backfilling differing. These are summarised in **Table 1.3**.



Table 1.3 Summary of effects of a disposal facility for HLW and SF

Objective	Summary of effects of a disposal facility for HLW and SF
<p>Landscape and Visual</p>	<p>The scale of the proposed scheme would be an important factor in landscape and visual terms. Above ground structures during construction and operation could include earthworks, access routes, bridges, railways and associated equipment, surface buildings and security structures. The tallest elements on site are likely to be the head-frames associated with the shafts. These would appear as solid structures approximately 35m tall and would be visible over considerable distances.</p> <p>The spoil from underground excavations would be used to create mounds for screening purposes. The most significant effects are likely to occur during the construction phase, during which site clearance and levelling would result in the loss of existing features in the landscape (e.g. vegetation or local topography). The introduction of the infrastructure including lighting and access roads or rail tracks may also result in a change in landscape characteristics from a green-field site to a more industrial landscape.</p>
<p>Cultural Heritage</p>	<p>Potential effects may arise during site investigation or as a result of transport infrastructure and could include the direct loss of visible historic above ground archaeological or historic features. Effects on the settings and amenity of visible historic or archaeological features may also occur. There is a potential threat from the direct loss of / or damage to buried or below ground archaeological features as a result of disturbance during site investigations, construction, operation and closure activities.</p> <p>There may be an indirect effect on below ground archaeology as a result of change in the subsurface hydrological regime or ground contamination. Historic landscapes may be affected by the introduction of new surface infrastructure and the introduction of landscaping using spoil material from excavation activities.</p>
<p>Geology and Soils</p>	<p>The most significant effect associated with the construction of the disposal facility in geological terms is from the excavation of significant quantities of material. This is assumed to be stored in landscaped mounds on site and may be used during the backfilling and closure process. Some rocks may be from important national mineral resources or may be recognised for their geological importance as RIGS or SSSIs. Effects on such designated sites are site-specific and will require further consideration once suitable sites have been identified.</p> <p>Construction of the facility would result in the loss of topsoil from the working areas (approximately 400x200m during construction). There is potential for the construction worksite to be located wholly or in part, on high quality agricultural land. The magnitude of this effect is potentially high given the area and volume of material affected.</p>
<p>Water Resources</p>	<p>The magnitude of the effects arising at the construction site is potentially high given the scale of the development. However, this would be reduced by the identification of a suitable location for the facility through the extensive site investigation proposed and the implementation of reasonable measures to control the rate of runoff, the careful identification of water sources for use on site and the provisions made in the design for treatment and analysis of discharged water.</p> <p>During operation, the key additional effect would be drainage from the filled vaults. This would be controlled through the implementation of the proposed effluent treatment and analysis measures and through the established system in place for consent of discharges by the relevant agency.</p> <p>Indeed, the design would include a drainage effluent treatment facility, whilst surface runoff would be collected separately from other waste streams and its constituents analysed. This runoff would only be mixed with other streams of liquid effluent if radiologically and chemically justifiable.</p> <p>Following closure, the buffer material would continue to act as a means of restricting groundwater flow and the disposal canisters are assumed to remain intact for in the order of 100,000 years. Therefore, water flow through the waste itself is considered to be very unlikely.</p>



Objective	Summary of effects of a disposal facility for HLW and SF
Ecology and Nature Conservation	<p>Effects on ecology and nature conservation may include wildlife mortality during the site characterisation, construction, operation and closure activities, or due to the transport of waste, as a result of collisions with traffic or the possible release of pollutants.</p> <p>Furthermore, there may be a loss of habitats or habitat fragmentation as a result of the introduction of new surface facilities during construction and operation. However, habitat creation or enhancement may be provided as part of the proposed development on the site, for example creation of large mounds of spoil.</p> <p>There may be a disturbance to the condition of areas and/or habitats of nature conservation value during site characterisation, construction, operation, and closure activities, or from the transport of waste from waste-producing sites to the facility. This may arise in the form of changes in air quality, light pollution, or dust deposition, or hydrological changes affecting either surface or ground waters.</p> <p>Disturbance to the effects on species of nature conservation value. This may result from the changes in conditions of habitats, changes in noise, vibration or water quality, habitat fragmentation and the changes in the number of predators and/or prey.</p>
Traffic and Transport	<p>The facility would require infrastructure to support the delivery of waste packages, potentially by road or rail. The assessment assumed transport by rail as the most likely case. Non-waste travel by all modes (car, HGV and bus) would account for an estimated 0.73 to 3.05 million km of network travel per year. The lower figure being that during care and maintenance whilst the higher figure would be during the initial construction phase. Non-waste transport is unlikely to have a material effect on the national motorway network, although traffic associated with construction works may have a significant effect on A roads and minor roads leading to the site.</p> <p>The maximum number of trains associated with the waste transport equates to some 4 trains per week. This would be negligible in terms of the effect on the existing rail network.</p>
Air Quality and Climate	<p>There may be temporary dust effects from construction if unmanaged. There may be effects on air quality from vehicle movements particularly during peak activities on sites. In terms of regional emissions, it is estimated that during the initial 9 year construction phase prior to waste emplacement, a total of 3.44 million km would be travelled for lorries, 23.98 million km for cars and 0.80 million km for buses. During the subsequent 53 years of construction and operation this would increase. Emissions from waste transport could vary up to nearly 28,400 kg CO₂ and 5,576 kg of particulate matter.</p>
Noise and Vibration	<p>There are likely to be a number of activities, which will result in perceptible changes in noise. Effects would be more perceptible at night time further from the facility than during the day. It is assumed that the closest sensitive receptors to the sites are likely to be individuals using rights of way across public open space, in areas adjacent to the site. In the absence of mitigation, effects may be observed at receptors up to 2.8 km away at night time during the initial construction phase. Whilst mitigation measures may help reduce the effects of noise, the significance of noise levels is dependent on the local setting. The effects of vibration are likely to be limited to acceptable levels through the implementation of appropriate mitigation measures, although it is uncertain whether this addresses vibrations from rock blasting.</p>
Socio-economics and Land Use	<p>There is anticipated to be a significant positive effect from the creation of a number of jobs, up to 370 for 9 years and up to 500 for 53 years, during construction and operation. It is recognised that the indirect effects on employment would spread over a large area and may extend regionally, nationally or internationally. There could be a permanent loss of between 93 and 144 ha, with greatest land use effects occurring during construction.</p>
Health and Safety	<p>A number of potential hazards were identified as issues that may arise, particularly during construction and operational activities including electrical hazards causing a fire, structural instability, exposure to hazardous substances and loss of ventilation.</p>
Resource Use, Utilities and Services	<p>There is likely to be a substantial increase in the use of energy and other resources, particularly during construction.</p>



Sustainability appraisal of initial surface-based site investigations

In 2008, a Sustainability Appraisal ^[18] was undertaken to identify the significant effects that were likely to arise from surface-based investigations works associated with a disposal facility. The surface-based investigations would follow the desk based studies stage of implementation of a disposal facility concept and were anticipated to occur at two separate geographical locations with works lasting approximately 10 years. The works would involve the construction of a number of drilling pads from which a number of borehole drilling campaigns would be commenced with up to 20 deep boreholes (up to 1,000m depth) and 50 shallow boreholes (less than 100m).

The objectives used for the assessment of the PGRC for ILW and LLW were reviewed to ensure that they remained relevant. Some amendments were made, including splitting some objectives to ensure they were consistent with the SEA Directive, evolving best practice and were appropriate for the assessment of the surface-based site investigations. Consequently, the proposed surface-based investigations were assessed against 15 objectives. These objectives were supported by detailed criteria to guide the assessment.

Against a number of objectives the effects were considered unlikely to be significant due to the limited and localised scale of the activities proposed. However, key effects were identified for each phase of the surface-based investigation. Most detrimental effects were anticipated to arise during the borehole drilling campaigns. The predicted effects mostly arose against topics such as waste, landscape, water and traffic and transport, and predominantly occurred as a result of the construction and operation of borehole drilling infrastructure. A summary of effects is provided in **Table 1.4**.

Table 1.4 Summary of effects of surface-based investigations

Objective	Summary of effects of surface-based investigations
Planning and Policies	There is likely to be a positive effect as the programme is the start of the implementation of the long-term management of hazardous waste in a sustainable manner and is therefore likely to have a positive effect on contributing to the Government's aims of sustainable development. The activities are also likely to contribute to achieving a number of policies such as the Government's Waste Strategy (2007).
Landscape and Visual	There is potential for a negative effect on landscape and visual amenity to arise from the cumulative effect of the drilling pads and associated drilling equipment, the access roads and office compound. This is due to the potential contrast between the activities and the assumed green-field and rural setting of the proposed sites, although there is considerable uncertainty associated with the significance of any effects at this stage due to the uncertainties on site location.
Cultural Heritage	There may be potential effects during the drilling campaigns. However, these depend on the receiving environment, which is unknown at present. Consequently, the effects are considered to be uncertain.
Geology and Soils	There may be a positive effect from the flattening of the site during drilling works as it may reduce the soil erosion by surface run-off during precipitation.



Objective	Summary of effects of surface-based investigations
Water Resources	<p>There is potential for there to be a negative effect as a result of an increase in demand on mains supply for the central office compound (up to 16 l/employee/day, equivalent to approximately 2,400 l/day assuming 150 staff) and the potential 'industrial' water use of 1000 m³ per borehole for part of the drilling fluid.</p> <p>There is also likely to be a negative effect due to the disruption of natural drainage and the increased risk of silty discharge during construction works. The drilling works are also likely to result in a significantly increased risk of spillages that may contaminate natural surface and groundwater supplies. Post-completion testing is also anticipated to require prolonged periods of pumping groundwater, which although low in volume, may result in a cumulative detrimental effect.</p>
Ecology and Nature Conservation	<p>The effects on biodiversity are dependent on site-specific data, which is unknown at this stage. Therefore the effects are considered uncertain.</p>
Traffic and Transport	<p>It is anticipated that there will be a negative effect due to possible short-term traffic disruption on rural roads from the surveys being undertaken. During the drilling campaigns, there is the potential for negative effects due to the likely increase of heavy plant construction vehicles operating in the area to prepare the drill sites and associated infrastructure. There will also be up to 10 HGV movements per week to each drilling location during the drilling period of 6 months (resulting in 260 movements in total). There is also anticipated to be a detrimental effect from the increased vehicle flows from staff travelling to the central office compound and an estimated 4 vehicle movements per day 7 days a week for 6 months to transport the crew to the drill site.</p> <p>There is potential for a positive effect on the condition of local roads as a result of the potential upgrading of some to meet the needs for additional traffic movements.</p>
Air Quality	<p>There may be some effects on air quality from the emission of dust during earth movement and drilling activities. However, it is considered to be uncertain at present, as the effects depend on the sensitivity of local receptors.</p>
Climate	<p>It is considered that the effects on the climate will be negligible as none of the activities will be of sufficient magnitude to have a significant effect.</p>
Noise and Vibration	<p>Noise is dependent on the location and sensitivity of receptors to the works being undertaken. Consequently, the effects are considered uncertain at this stage until more specific site details are identified.</p>
Land Use	<p>Most effects are likely to arise during the drilling campaigns. The sixteen drilling pads (of up to 4,000m²) will be required at each of the two selected sites which will result in the loss of approximately 6.4 ha, or less than 0.2% of the total site area. The significance of the effect is dependent on the receiving environment which is unknown at present and is therefore considered to be uncertain.</p>
Socio-economics	<p>There may be some positive effects from the increased employment. However, overall it is considered that there will be an uncertain effect against the objective as the extent of the increased economic and employment activity in the area is dependent on the existing site-specific baseline.</p>
Health and Safety	<p>It is unlikely that there would be a change in the health and safety levels to third parties. Whilst the work may present a number of hazards to the work force, the contractors will be fully trained and professionals who are used to working in such environments. Consequently, adequate measures will be implemented to reduce the risk so far as possible. As such, any effects are considered to be negligible.</p>
Waste	<p>There is potential for a negative effect from the generation of various wastes. It is anticipated that from a combined drilling of 25,000 m (from the 20 boreholes) over 6 years, there would be up to 600m³ of drill cuttings; up to 1,800m³ of drilling fluid; up to 2,100m³ of test water; and up to 3,000m³ of construction waste. It is also anticipated that there will be an increase in wastes generated from machinery lubricants, oils and greases, excess cement from casing installations, fuels, and component packaging. Some general office waste such as paper, organic canteen wastes, packaging and electrical products are likely to be generated throughout the duration of the programme.</p>



Objective	Summary of effects of surface-based investigations
Resource Use, Utilities and Services	Whilst there may be some effects, (which are predominantly captured by the effects identified under waste and water use objectives) arising from the drilling campaigns, overall it is considered that there will be a negligible effect on resource use, utilities and services.

1.3.2 Building on the previous studies

During the early stages of the MRWS Site Selection Process (refer to **Figure 1.1**), the NDA has committed to complete a generic (i.e. not site-specific) SEA of illustrative geological disposal concepts developed for three host rock types (higher strength rock, lower strength sedimentary rock and evaporite rock) as described in the report on Generic disposal facility designs prepared by the NDA ^[8] (refer to **Section 1.2.4** and **Section 2**).

This report presents the findings of the generic SEA and considers potential environmental and socio-economic effects of a GDF in the context of defined sustainability objectives. Development of the objectives has been informed by, and builds on, the previous assessment work undertaken for the non-radiological assessment of geological disposal concepts to date.

The findings of the generic SEA will be used to influence the development of geological disposal concepts and to provide information on potential non-radiological effects to communities that have expressed an interest (or are considering expressing an interest) in participating in the site selection process and in hosting a GDF. The NDA is actively engaging with these communities to understand their needs.

The generic SEA and this report are not part of a formal, statutory assessment process. In consequence, while some aspects of the generic SEA work detailed in this report are in line with the UK SEA Regulations, the work and this report do not seek to be fully compliant with statutory requirements.

A formal, statutory SEA will be undertaken following a community decision to participate in the site selection process. It is anticipated that such an assessment would build on the work in this report, using the potential effects that have been identified and assessed to inform the scope of the work.

The potential radiological effects of implementing a GDF are being considered as part of a Generic Disposal System Safety Case which is being developed for the geological disposal programme. The NDA is in the process of producing a comprehensive suite of documents underpinning the safety case which will describe potential radiological (and associated chemo-toxic) effects associated with the packaging and transport of radioactive waste, the conduct of construction and operations at a GDF (including non-radiological safety), the eventual closure of a GDF and the longer-term post-closure phase. The assessments in this report do not seek to duplicate the safety case work. During future stages of the programme, radiological issues would be incorporated into the environmental and socio-economic assessment work.



More detailed information on the scope of the generic SEA is provided in **Section 2**.

1.4 Consultation

The NDA is committed to engaging and consulting with stakeholders throughout the development of geological disposal concepts. A strategy for the engagement of stakeholders and the public has been established ^[21], which sets out how often and at what level to engage with stakeholders and the public. The NDA has also adopted a code of practice in relation to undertaking engagement, based on Government guidance ^[22]. The NDA's strategy on sustainability appraisal and environmental assessment ^[14] highlights the stages during the MRWS programme at which consultation on the assessments is considered appropriate.

This Generic Environmental and Sustainability Report has been peer reviewed by an independent advisory panel including representatives of statutory consultee organisations, and technical specialists. It will also be made publicly available in autumn 2010. The NDA's strategy for sustainability appraisal and environmental assessment ^[14] highlights the importance of enabling interested parties to comment on the reports produced. The Strategy also sets out the importance of providing feedback to stakeholders on how their views have been taken into account or acknowledged. A report will therefore be produced summarising stakeholder views on the findings of the generic SEA. Comments received will be fed into the further development of geological disposal concepts and will be considered in the statutory SEA process during MRWS Stage 4.



2. Illustrative geological disposal concepts

2.1 Introduction

This section provides a brief explanation of the generic illustrative geological disposal concepts that are being developed by the NDA for three host rock types (higher strength rock, lower strength sedimentary rock, and evaporite rock) – refer to **Section 1.2.4** and **Table 1.1**.

Sections 2.2 to 2.7 set out the key elements of the illustrative geological disposal concepts and associated activities during the four phases of implementation that have been considered in this assessment (surface-based site investigations, construction, operation, and closure & post-closure). Further information on the illustrative geological disposal concept design requirements for the different waste inventories and host rock types, and information on each of the phases is provided in the detailed assessments in **Appendix D**.

In order to develop illustrative geological disposal concept designs, a number of assumptions have been made about host rock types, the layout of a GDF and how a GDF programme would be implemented. These assumptions are purely for planning purposes and to enable designs to be developed. They do not pre-empt the outcome of the MRWS site selection process. They are outlined in the NDA report on Generic disposal facility designs ^[8].

It should be noted that assumptions made about the storage and use of excavated rock vary for the different host rock types. With the exception of the evaporite rock type, a proportion of the host rock excavated from the construction of underground facilities would be stored on site in surface bunds. For the evaporite rock type, none of the excavated rock would be suitable for surface bunding or for landscaping and therefore any surface bunds required to screen the site would need to be constructed using spoil from the construction works (e.g. from top-soil stripping), or material may need to be imported to the site for this purpose. Any surface bunds are therefore assumed to be only of a sufficient scale to screen the site (rather than act as a ‘store’ for excavated material). However, because excavated evaporite rock would be required for backfilling during the operational and closure phases, an on-site dedicated storage facility would be required.

For the higher strength rock and evaporite rock types, the excavated host rock would meet crushed rock backfilling requirements for the HLW/SF disposal tunnels during the operational phase, and for the backfilling of the access tunnels (drift and/or shafts) and common service areas during the closure phase, negating the need to import any crushed rock for these purposes. Lower strength sedimentary rock would not be suitable for backfilling and therefore all backfill material would need to be imported.

The exact quantities of crushed rock material required for backfilling the remaining underground roadways and facilities are not available at this stage. Therefore, in the case of the higher strength rock and evaporite rock it is unknown whether crushed rock backfill requirements for these purposes could be met using excavated rock from the construction of the underground facilities.



2.2 Surface-based site investigation

Initially, a range of detailed surface-based investigations would be undertaken to gather information about the geological, hydrogeological and environmental conditions at one or more potential sites. The information acquired would inform the development of a safety case and engineering designs for a GDF, and would assist with the selection of a suitable site and design.

For the assessment of the surface-based site investigation phase, it has been assumed that the work would involve:

- **Regional surveys** –airborne and satellite surveys, geophysical surveys and surface mapping over a 1 year period);
- **Deep borehole construction** – the construction of up to 20 deep boreholes (>1,000m) and 50 shallow (<100m) boreholes, drilled over 3 phases at two candidate sites (approximately 50km² each) over an 8 year period;
- **Post completion testing** – testing of a small number of boreholes (geophysical tomography, hydrological testing and large scale pumping tests) to address any significant remaining uncertainties, over a 4 year period; and
- **Baseline monitoring** (the final stage of the investigations) –monitoring of the groundwater system for a period of 2 years to establish baseline conditions.

The total duration of the surface-based site investigation phase is estimated to be approximately 10 years (with substantial overlap of consecutive stages anticipated).

Although the scope of the surface-based site investigations would be broadly similar for each of the three host rock types, there may be differences in the implementation of surface-based site investigations, as follows:

- For higher strength rock, if the host rock extends to surface it may be appropriate to use relatively small mobile drilling rigs as such boreholes can be drilled at a relatively small diameter with less steel casing required. Compared with the larger drilling rigs which would be required for the other host rock types, such small rigs require fewer drilling crew, a smaller footprint, less supporting infrastructure and can be operated during daylight hours (compared with 24/7 working for larger drilling rigs). As such there is the potential for reduced environmental impacts when using such equipment. This assessment however considers the potential impacts associated with the larger type of drilling rig because the illustrative geological disposal concepts considered at this stage assume that the host rock type does not outcrop at the surface.
- Site investigations for lower strength sedimentary rock, by nature of their relatively homogeneous (uniform) structure and composition, may require fewer deep boreholes to be constructed (in comparison to site investigations for higher strength rock), with a greater reliance on geophysical surveys. As such there is the potential for reduced local impacts by nature of the reduced number of borehole locations.



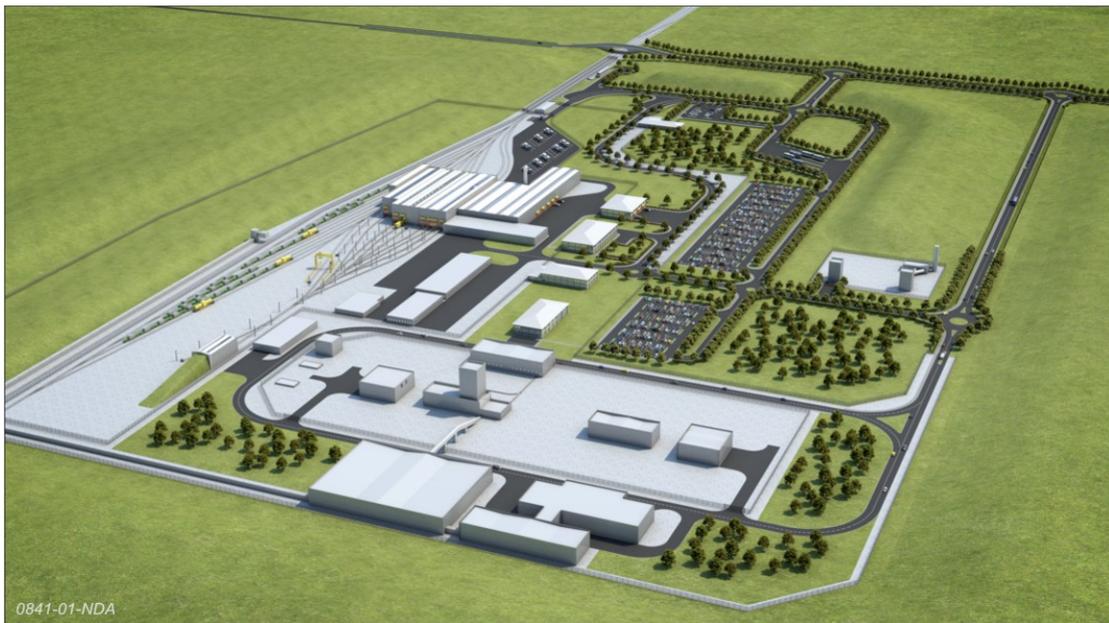
It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.

2.3 Construction

Following completion of the surface-based site investigations and public endorsement of a preferred location and design, it is assumed that the construction of a GDF would commence.

It has been assumed that a single surface site would be constructed to accept, transfer and transport ILW, LLW, HLW, SF, Pu and U for disposal. A GDF would consist of surface buildings and infrastructure, an access road, rail infrastructure, underground accesses (a drift and/or several shafts) and separate waste disposal areas for ILW/LLW (vaults) and HLW/SF (disposal tunnels) connected by roadways and service tunnels. An illustrative aerial view of surface facilities for a GDF is shown in **Figure 2.1**.

Figure 2.1 Illustrative aerial view of surface facilities for a GDF



Source: NDA (2010)

Initial facility construction would take place over a period of around 10 years, during which time all of the underground accesses (drift and/or shafts) would be constructed as well as the first ILW/LLW vaults. Thereafter ILW/LLW vaults and subsequently disposal tunnels for HLW/SF would be constructed as required.



2.3.1 Assumed host rock types

- For higher strength rock, the host geology is assumed to be in a higher strength rock comprising crystalline igneous and metamorphic rocks or geologically older sedimentary rocks where any fluid movement is predominantly through discontinuities.
- For lower strength sedimentary rock, the host geology is assumed to be a lower strength sedimentary rock comprising geologically younger argillaceous sedimentary rocks (e.g. rocks with high clay content) where any fluid movement is predominantly through the rock matrix.
- For evaporite rock, the host geology is assumed to comprise anhydrite (anhydrous calcium sulphate), halite (rock salt) or other evaporites that result from the evaporation of water from waterbodies containing dissolved salts.

For all host rock types for the purposes of the assessment the host rock is assumed to be overlain by a variable sequence of sedimentary strata. However, it should be noted that in the case of higher strength rock the host rock could extend to the surface.

2.4 Operation

Following initial construction, a GDF would enter its operational phase. The key activities assumed to take place throughout the operational phase are the ongoing construction of the ILW/LLW vaults and HLW/SF disposal tunnels on an “as required” basis, the transport and emplacement of the radioactive waste into the waste disposal areas, and the subsequent backfilling of the waste disposal areas. The emplacement of radioactive waste is anticipated to begin in 2040 and potentially continue until 2128. It is assumed that ILW/LLW waste disposal would commence from 2040, HLW/SF disposal from 2075, and Pu/U disposal would commence from ~2123.

For the purposes of the generic SEA, the effects of disposing of the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory waste volumes within an illustrative concept GDF for each host rock have been considered as, for planning purposes, these have been assumed to represent reasonable lower and upper size limits for a facility. However, it is recognised that these scenarios are not bounding and the inventory for disposal will ultimately be decided by Government in consultation with potential host communities. The mid-level waste inventory, ‘the Derived Inventory Reference Case’, is not considered further in this assessment.

The Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory waste volumes for disposal are outlined in the NDA report on Generic disposal facility designs^[8] and are summarised in **Section 2.4.1** below. The waste volumes would not vary for the different host rock types.



2.4.1 Radioactive waste volumes for disposal

Derived Inventory Reference Case excluding Pu/U - waste volumes for disposal

This would include ILW, LLW, HLW and SF, the latter comprising vitrified HLW and SF from Advanced Gas-cooled Reactors (AGR) and Pressurised Water Reactors (PWR). The packaged waste volumes¹¹ for each of the waste streams are anticipated to be as follows:

- 361,692m³ of ILW, 239,827m³ of which would be unshielded¹² ILW and 121,865m³ of which would be shielded¹³ ILW;
- 16,632m³ of LLW;
- 7,457m³ of HLW; and
- 10,363m³ of SF, consisting of 8,491m³ of AGR and 1,872m³ of PWR.

Derived Inventory Upper Inventory waste volumes for disposal

This would include ILW, LLW, HLW, SF, Pu and U, including potential new build ILW, U and SF that might be produced from a programme of new civil nuclear power stations. The packaged waste volumes for each of the waste streams are anticipated to be as follows:

- 559,083m³ of ILW, 401,469m³ of which would be unshielded¹² ILW and 157,614m³ of which would be shielded¹³ ILW;
- 155,843m³ of LLW;
- 23,026m³ of HLW;
- 2,097m³ of SF consisting of 1,848m³ of Sellafield Miscellaneous, 45m³ of PWR and 204m³ of submarines;
- 20,228m³ of New Build SF;

¹¹ The **packaged volume** consists of the waste material, the encapsulating matrix, capping grout and ullage (the volume in the container which is not occupied by the waste), and the container.

¹² An **unshielded waste package** is one that, owing either to radiation levels or containment requirements, requires remote handling and must be transported in a reusable transport container (the container and contents then forming a Type B transport package).

¹³ A **shielded waste package** is one that either has in-built shielding or contains low activity materials, and thus may be handled by conventional techniques. In most cases, shielded waste packages are also designed to qualify as transport packages in their own right.



- 10,401m³ of Pu;
- 118,729m³ of U, consisting of 1,683m³ of HEU and 117,046m³ of Depleted Uranium (DU);
- 24,896m³ of New Build ILW; and
- 56,372m³ of New Build U.

Following the emplacement of the radioactive wastes, the waste disposal areas would be backfilled. The timing of backfilling would vary depending on the host rock type. In the case of higher strength rock, the ILW/LLW vaults would be backfilled shortly after the emplacement of all of the ILW/LLW, whereas the backfilling of the HLW/SF disposal tunnels would take place when all deposition holes were filled in a particular tunnel. In the case of lower strength sedimentary rock, backfilling of the ILW/LLW vaults and HLW/SF disposal tunnels would take place as each ILW/LLW vault or HLW/SF disposal tunnel was filled. In the case of evaporite rock, due to the nature of the host evaporite rock, there would not be any requirement for backfilling of the ILW/LLW vaults. Instead the strata would be allowed to creep into the ILW/LLW vaults to fill any voids. The evaporite rock HLW/SF disposal tunnels would be backfilled progressively as canisters were placed.

For the purposes of this assessment, although the backfilling programme would vary, the backfilling of the ILW/LLW vaults and the HLW/LLW disposal tunnels has been considered in the operational phase assessment.

A summary of the waste disposal and waste buffer/backfill assumptions for the illustrative geological disposal concepts for each host rock type is provided in **Appendix D**.

2.5 Closure and post-closure

Following the emplacement of all of the radioactive waste, and following a period of aftercare and maintenance, it is assumed that the facility operators, in consultation with the candidate community, would seal and close the underground facility, and decommission the surface facilities and infrastructure. The site would then be restored to as near its preconstruction condition as practicable. The only structures that are assumed to remain on site are the surface bunds.

At the time of closure, it is assumed for the purposes of the assessment for all three host rock types that the ILW/LLW vaults and HLW/SF disposal tunnels would have been backfilled and/or sealed and therefore it would be necessary to progressively backfill the remaining underground roadways, facilities (workshops etc), and access tunnels (drift and/or shafts).

Backfilling, sealing and closure of the remaining underground facilities is assumed to take place over a 10 year period.



2.6 Summary of Geological Disposal Facility design for each rock type

Table 2.1 provides a summary of the design and construction specifications for each host rock type, provided in the NDA report on Generic disposal facility designs ^[8], which have been used to inform the assessment. Information for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory are presented. Please note that it is assumed that the surface-based site investigations would be the same for each host rock type.

The estimated figures quoted for backfill in **Table 2.1** relate to the backfilling of the ILW/LLW vaults and HLW/SF disposal tunnels only. Estimated volumes of material for the backfilling of the access tunnels (drift and/or shafts) and common services area (which would take place during the closure and post-closure phase) have been estimated by the NDA to inform the assessment process and are provided in **Section 2.7**. Backfill volumes for the remaining underground roadways and facilities are not available at this stage; however they will be required during future stages of assessment.

Table 2.1 Summary of the illustrative geological disposal concept specifications for each host rock type

Description	Higher strength rock	Lower strength sedimentary rock	Evaporite rock
Surface facility footprint	1.1km ² for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory	1.1km ² for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory	0.5 - 1.1km ² for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory
Underground facility depth	650m (assumed to be between 200m and 1000m)	500m (assumed to be between 200m and 1000m)	650m (assumed to be between 200m and 1000m)
Underground facility footprint (based on the ILW/LLW vaults, HLW/SF disposal tunnels, and roadways and support area footprints)	4.3km ² for the Derived Inventory Reference Case excluding Pu/U 9.8km ² for the Derived Inventory Upper Inventory	7.8km ² for the Derived Inventory Reference Case excluding Pu/U 19.5km ² for the Derived Inventory Upper Inventory	6.5km ² for the Derived Inventory Reference Case excluding Pu/U 18.4km ² for the Derived Inventory Upper Inventory
Construction period	10 years (during which the drift, shafts and the first ILW/LLW vaults would be constructed)	10 years (during which the drift, shafts and the first ILW/LLW vaults would be constructed)	10 years (during which the shafts and the first ILW/LLW vaults would be constructed)
Excavation methods	Drill and blast	Combination of tunnel boring machine, road header and drill and blast	Continuous miner and/or road header
Underground access	1 drift and 3 shafts	1 drift and 3 shafts	4 shafts
Drift dimensions	Gradient of 1 in 6 4km long and 5.5m diameter for 1800m and then 'D' shaped (5.5m high by 5m wide) to facility horizon	Gradient of 1 in 6 3km long and 5.5m diameter	Not applicable, as the outline design for the evaporite rock does not include a drift. Instead an additional shaft would be constructed



Description	Higher strength rock	Lower strength sedimentary rock	Evaporite rock
Shaft lining	Concrete hydrostatic lining and nominal concrete lining and/or steel mesh and rock bolting where lining is not required	Concrete hydrostatic lining and nominal concrete lining and/or steel mesh and rock bolting where lining is not required	Concrete hydrostatic lining and nominal concrete lining and/or steel mesh and rock bolting where lining is not required
Waste encapsulation arrangements	All waste to be packaged off-site	All waste to be packaged off-site	All waste to be packaged off-site
Waste emplacement programme	ILW/LLW disposal to commence 2040. HLW/SF disposal to commence 2075. Pu/U disposal to commence 2136.	ILW/LLW disposal to commence 2040. HLW/SF disposal to commence 2075. Pu/U disposal to commence 2136.	ILW/LLW disposal to commence 2040. Pu/U disposal to commence 2136.
ILW/LLW vault buffer material	Nirex Reference Vault Backfill (NRVB) ¹⁴	NRVB	Sacks of Magnesium Oxide (MgO) ¹⁵ to be placed on top of waste package stack as waste is progressively placed
ILW/LLW vault buffer volumes	1,000,000m ³ of NRVB for the Derived Inventory Reference Case excluding Pu/U 2,300,000m ³ of NRVB for the Derived Inventory Upper Inventory <i>(combined figure for buffer and backfill)</i>	1,050,000m ³ of NRVB for the Derived Inventory Reference Case excluding Pu/U 2,540,000m ³ of NRVB for the Derived Inventory Upper Inventory <i>(combined figure for buffer and backfill)</i>	144,000m ³ of MgO for the Derived Inventory Reference Case excluding Pu/U 356,000m ³ of MgO for the Derived Inventory Upper Inventory
ILW/LLW vault backfill material	NRVB	NRVB	Due to the nature of the host rock there would not be any requirement for local or peripheral backfill
ILW/LLW vault backfill material volumes	See buffer volumes <i>(combined figure for buffer and backfill)</i>	See buffer volumes <i>(combined figure for buffer and backfill)</i>	None required – see above
HLW/SF buffer material	Pre-compacted bentonite blocks and rings	Pre-compacted bentonite blocks and pellets	Crushed salt
HLW/SF buffer volumes	204,000m ³ of bentonite for the Derived Inventory Reference Case excluding Pu/U 656,000m ³ of bentonite for the Derived Inventory Upper Inventory	257,000m ³ of bentonite for the Derived Inventory Reference Case excluding Pu/U 731,000m ³ of bentonite for the Derived Inventory Upper Inventory <i>(combined figure for buffer and backfill)</i>	872,000m ³ of crushed rock salt for the Derived Inventory Reference Case excluding Pu/U 2,516,000m ³ of crushed rock salt for the Derived Inventory Upper Inventory <i>(combined figure for buffer and backfill)</i>
HLW/SF disposal tunnel backfill material	Crushed rock and bentonite with backfill ratio of 70:30	Bentonite pellets	Crushed rock salt

¹⁴ Nirex Reference Vault Backfill (NRVB) is a specified mix of Portland cement, hydrated lime, limestone flour and water.

¹⁵ Magnesium Oxide (MgO) is a chemical compound comprising magnesium and oxygen.



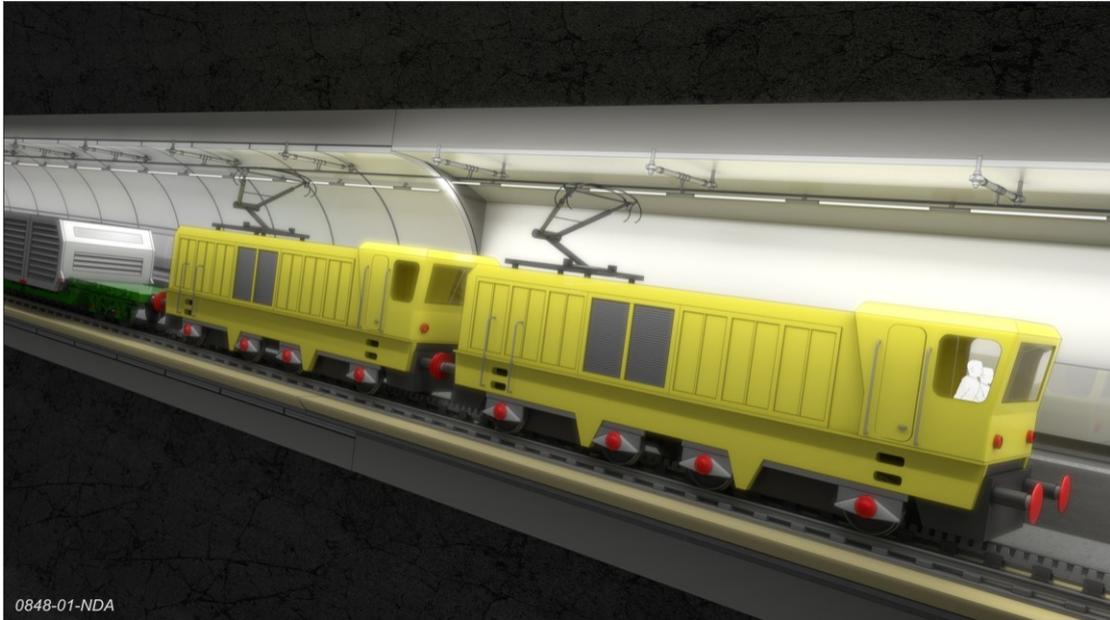
Description	Higher strength rock	Lower strength sedimentary rock	Evaporite rock
HLW/SF disposal tunnel backfill material volumes	510,000m ³ of bentonite and 1,190,000m ³ of crushed rock for the Derived Inventory Reference Case excluding Pu/U (1,700,000m ³ of material in total) 1,290,000m ³ of bentonite and 3,010,000m ³ of crushed rock for the Derived Inventory Upper Inventory (4,300,000m ³ of material in total)	See buffer volumes (<i>combined figure for buffer and backfill</i>)	See buffer volumes (<i>combined figure for buffer and backfill</i>)
Closure programme	Single campaign of backfilling, sealing and closure of 10 years	Single campaign of backfilling, sealing and closure of 10 years	Single campaign of backfilling, sealing and closure of 10 years
Closure backfilling requirements	Progressive backfilling of the ILW/LLW vaults ¹⁶ , the remaining underground roadways, facilities (workshops etc), shafts and drift	Progressive backfilling of the remaining underground roadways, facilities (workshops etc), shafts and drift	Progressive backfilling of the remaining underground roadways, facilities (workshops etc) and shafts
Mass backfill material	Crushed rock	Bentonite and sand (30:70 mix)	Crushed rock salt
Mass backfill volumes ⁸	Not available	Not available	Not available

An indicative illustration of an underground drift is shown in **Figure 2.2**. Indicative illustrations for waste disposal areas in each of the host rock types are illustrated in **Appendix A**.

¹⁶ As noted in **Section 2.4.1**, the timing of backfilling of the waste disposal areas would vary depending on the host rock type. In the case of the higher strength rock scenario, the ILW/LLW vaults would be backfilled on the emplacement of all of the ILW/LLW within a GDF, whereas the backfilling of the HLW/SF disposal tunnels would take place when all deposition holes are filled in a particular tunnel. In the case of the lower strength sedimentary rock and evaporite rock scenarios, backfilling of the ILW/LLW vaults and/or the HLW/SF disposal tunnels would take place as each waste disposal area is filled. For the purposes of this assessment, although the backfilling programme would vary, the backfilling of the ILW/LLW vaults and the HLW/SF disposal tunnels has been considered in the operational phase assessment.



Figure 2.2 Indicative illustration of a drift



Source: NDA (2010)

2.7 Assumptions

2.7.1 General assumptions

For the purposes of the assessment of the illustrative geological disposal concepts for each of the host rock types it is assumed that the development would be in a greenfield location with no previous history of contamination.

2.7.2 Employment assumptions

In terms of direct employment, the NDA has provided manpower estimates as follows:

- It is assumed that, on average, 886 people per year could be employed during the construction phase, of which an estimated 806 people would be directly involved in construction.
- It is assumed that, on average, 623 people per year could be employed during the operational phase (including manpower for further construction).
- It is assumed that, on average, 379 people per year could be employed during the closure and post-closure phase.



It is assumed that the level of employment would be the same for the different waste inventories, as the scale of the activities would not increase on an annual basis; instead a GDF would operate for a longer period.

Similarly, there is not considered to be any significant difference in employment opportunity between the different host rock types. The excavation technique utilised for the construction of the underground facilities could vary between the host rock types. However, any excavation work would be specialist and therefore would not have any significant effect on potential local employment opportunities.

It is important to note that only a proportion of these jobs would represent local employment opportunities. At this stage it is not possible to define job locations or to assess whether certain skills and expertise would be available locally.

2.7.3 Transport and carbon assumptions

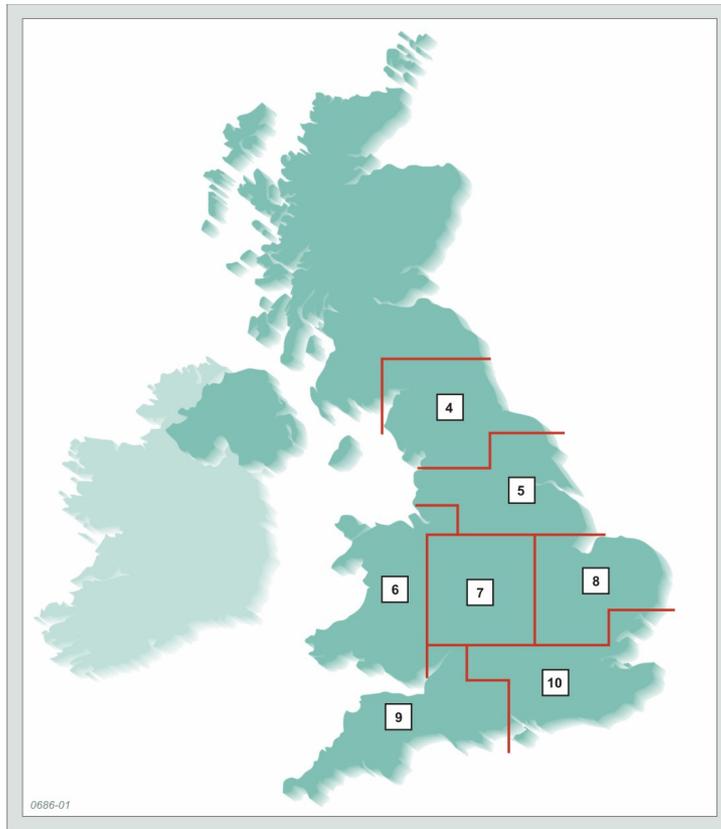
A range of scenarios are being considered by the NDA to transport the materials required to construct a GDF and to transport radioactive waste for geological disposal, including rail, road and sea.

The Scottish Government currently supports long-term interim storage of HAW and therefore did not sponsor the MRWS White Paper ^[4]. However, in order to take a precautionary approach wastes arising in Scotland are included in the Derived Inventories and therefore transport of wastes from Scotland to a GDF have been taken into account by the NDA.

The NDA has divided England, Wales and Northern Ireland into 7 arbitrary zones in any of which a GDF could be located. In determining transport distances the NDA has assumed that a GDF would be located at a central point in each of the zones. These assumptions are made purely for planning purposes and do not pre-empt the MRWS site selection process. These zones are shown in **Figure 2.4**. A detailed appreciation of the operation of transport systems for moving radioactive waste from the main waste producing establishments in the UK to a GDF in any one of the 7 zones, over a period of time commencing from ~2040, has been developed by the NDA ^[23].



Figure 2.3 Arbitrary zones for the location of a GDF



Source: NDA (2010)

The transport and carbon assumptions adopted in this assessment are those used in the *Generic Carbon Footprint Analysis* ^[24] produced alongside this generic SEA to inform Stage 3 of the MRWS site selection process.

For the purposes of this assessment, the following transport assumptions have been made:

- With the exception of any excavated rock, it is assumed that all construction materials, machinery and construction waste, and all buffer/backfill material would be transported to and from the site via road (which is considered to be a worst case scenario in terms of carbon footprint). The assumptions made for transport by road are as follows:
 - 10% of construction materials would be transported using a >3.5-7.5t HGV; 50% using a >7.5-17t HGV; and 40% using a >17t HGV.
 - 20% of backfill material would be transported using a >7.5-17t HGV, and 80% using a >17t HGV.
 - It is assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the site and may pass close to sensitive receptors such as residential areas.



- A 600km roundtrip is assumed for the transport of construction materials, plant equipment and buffer/backfill materials and a 100km roundtrip is assumed for contractor staff, consistent with the figures provided in the 'Geological Disposal – Generic transport system designs' report ^[23].
- It is assumed that all of the surplus excavated rock from the construction of the underground facilities would be transported from the site via rail.
- Two transport scenarios have been considered for the transport of radioactive wastes; Road/Rail and SeaRoadRail:
 - For the Road/Rail scenario, it is assumed that 70% of the radioactive waste would be transported to the site by rail, with the remaining 30% transported by road.
 - For the Sea/Road/Rail scenario, it is assumed that 80% of the radioactive waste would be transported to the site via ship, with the remaining 10% by road and 10% by rail.
 - A 600km roundtrip is assumed for the transport of radioactive waste packages, consistent with the figures provided in the 'Geological Disposal – Generic transport system designs' report ^[23].
 - It is assumed that existing port facilities would be utilised (i.e. no new sea transport infrastructure development would be required).

The carbon calculations are based primarily on information contained within the ODRs and underpinning data sheets supplied by the NDA, taking account of the above transport assumptions. The *Generic Carbon Footprint Analysis* ^[24] provides further information on the carbon assumptions made.

2.7.4 Higher strength rock assumptions

For the higher strength rock type the following assumptions have been made:

- It is estimated that approximately 5,225,000m³ of rock would be excavated for the construction of a GDF for the Derived Inventory Reference Case excluding Pu/U and 13,800,000m³ for the construction of a GDF for the Derived Inventory Upper Inventory. Of this, it is estimated that all of the excavated rock would be retained on site for the Derived Inventory Reference Case excluding Pu/U, and 7,159,079m³ of the excavated rock retained on site for the Derived Inventory Upper Inventory, to be used as follows:
 - 1,190,000m³ of excavated rock would be used as crushed rock backfill material for backfilling of the HLW/SF disposal tunnels for the Derived Inventory Reference Case excluding Pu/U, and 3,010,000m³ for the Derived Inventory Upper Inventory;
 - 263,771m³ of excavated rock would be used as crushed rock backfill material for backfilling the underground accesses (drift and shafts), and 296,308m³ of excavated rock would be used as crushed rock backfill material for backfilling the common services area for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory; and
 - Up to 3,589,000m³ of excavated rock would be stored on site in surface bunds for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory. It is estimated



that, once backfilling of the underground accesses (drift and shafts), and the commons services area is complete, 3,474,921m³ of excavated rock would remain on site in surface bunds for the Derived Inventory Reference Case excluding Pu/U, and 3,589,000m³ for the Derived Inventory Upper Inventory¹⁷.

- As waste disposal area construction would take place concurrently with disposal, and with waste disposal areas constructed on an “as required” basis, backfilling would begin before the surface bunds reached their maximum volume. Backfill material would be sourced from the surface bunds as required, although excavated material would continue to be added until the maximum volume of 3,589,000m³ for the surface bunds was reached.
- For the Derived Inventory Reference Case excluding Pu/U, all of the higher strength rock excavated during the construction of the underground facilities would be utilised on site (taking account of the volumes of excavated rock to be stored in surface bunds and used for backfilling of the HLW/SF disposal tunnels, the underground accesses, and the common services area). For the Derived Inventory Upper Inventory, not all of the excavated rock would be utilised on site. The surplus excavated rock, estimated to be approximately 6,640,921m³ would be transported off-site.
- The surface site area for a GDF is assumed to be approximately 1.1km² for the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory. The scale of surface development is assumed to be similar for the different waste inventories, as the maximum rate of waste package delivery to a GDF would not increase. Within this site area, the surface facilities and infrastructure would be constructed and up to 3,589,000m³ of excavated rock stored in surface bunds.
- The footprint of the underground facilities for a GDF is assumed to be at least 4.3km² for the Derived Inventory Reference Case excluding Pu/U and at least 9.8km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults, the HLW/SF disposal tunnels and the roadways and support area).

2.7.5 Lower strength sedimentary rock assumptions

For the lower strength sedimentary rock type the following assumptions have been made:

- It is estimated that approximately 4,820,000m³ of rock would be excavated for construction of a GDF for the Derived Inventory Reference Case excluding Pu/U and 11,775,000m³ for the construction of a GDF for the Derived Inventory Upper Inventory. Of this, for both the Derived Inventory Reference

¹⁷ For the Derived Inventory Reference Case, the estimated volumes of higher strength crushed rock that would remain on site following completion of the backfilling of the drift, shafts, and common services area, takes account of total excavated rock arisings (5,225,000m³) and crushed rock backfill requirements (1,750,079m³), which, when the total crushed rock backfill material is taken from the total excavated rock arisings, leaves a surplus of 3,474,921m³ of excavated rock retained on site in surface bunds. Until the backfilling of the underground accesses (drift and shafts), and common services area is completed (which would take place during the closure phase), it is assumed that up to 3,589,00m³ of excavated rock could be stored on site within surface bunds.



Case excluding Pu/U and the Derived Inventory Upper Inventory, 3,589,000m³ of the excavated rock would be used to progressively construct surface bunds around the site.

- The remainder of the excavated rock, estimated to be 1,231,000m³ for the Derived Inventory Reference Case excluding Pu/U, and 8,186,000m³ for the Derived Inventory Upper Inventory, would be transported off-site.
- The excavated lower strength sedimentary rock would not be suitable for backfilling and consequently would not be used for this purpose. Therefore it is assumed that all backfill material would need to be imported to the site.
- The surface site area for a GDF is assumed to be approximately 1.1km² for the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory. The scale of surface development is assumed to be similar for the different waste inventories, as the maximum rate of waste package delivery to a GDF would not increase. Within this site area, the surface facilities and infrastructure would be constructed and the 3,589,000m³ of excavated rock stored within surface bunds.
- The footprint of the underground facilities for a GDF is assumed to be at least 7.8km² for the Derived Inventory Reference Case excluding Pu/U and at least 19.5km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and the HLW/SF disposal tunnels and the roadways and support area).

2.7.6 Evaporite rock assumptions

For the evaporite rock type the following assumptions have been made:

- It is estimated that approximately 4,273,000m³ of rock would be excavated for construction of a GDF for the Derived Inventory Reference Case excluding Pu/U and 11,366,000m³ for the construction of a GDF for the Derived Inventory Upper Inventory. Of this, it is estimated that 1,172,121m³ of the excavated rock would be retained on site for the Derived Inventory Reference Case excluding Pu/U, and 2,816,121m³ for the Derived Inventory Upper Inventory, to be used as follows:
 - 872,000m³ of excavated rock would be used as crushed rock backfill material for backfilling of the HLW/SF disposal tunnels for the Derived Inventory Reference Case excluding Pu/U, and 2,516,000m³ for the Derived Inventory Upper Inventory;
 - 191,314m³ of excavated rock would be used as crushed rock backfill material for backfilling the underground accesses (shafts), and 108,807m³ for backfilling the common services area for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory.
- None of the excavated evaporite rock brought to the surface during construction could be used for the construction of surface bunds or for landscaping around the site. In the case of evaporite rock, any surface bunds required to screen the site would therefore need to be constructed using spoil from the construction works (e.g. from top-soil stripping) or material may need to be imported to the site for this purpose. Any surface bunds are therefore assumed to be only of a sufficient scale to screen the site (rather than act as a 'store' for excavated material).



- It is assumed that the excavated rock retained on site for backfilling would be stored in a suitably designed area within the surface site area.
- The remainder of the excavated rock, estimated to be 3,100,879m³ for the Derived Inventory Reference Case excluding Pu/U and 8,549,879m³ for the Derived Inventory Upper Inventory, would be transported off-site.
- The surface site area for a GDF is assumed to be approximately 0.5km² for the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory. The scale of surface development is assumed to be similar for the different waste inventories, as the maximum rate of waste package delivery to a GDF would not increase. Within this site area, the surface facilities and infrastructure, including a storage area for excavated rock, would be constructed. Should surface bunds be constructed, the surface site area for a GDF is assumed to be approximately 1.1km² for the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory.
- The footprint of the underground facilities for a GDF is assumed to be at least 6.5km² for the Derived Inventory Reference Case excluding Pu/U and at least 18.4km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and the HLW/SF disposal tunnels, and the roadways and support area).

A summary of the assumptions made regarding excavated rock arisings, including the usage of excavated rock, and the assumptions regarding buffer/backfill requirements for the different waste inventories and host rock types, is provided in **Table 2.2** below.



Table 2.2 Summary of excavated rock and buffer/backfill assumptions for the illustrative geological disposal concepts

Quantity assumptions (m ³)		Derived Inventory Reference Case excluding Pu/U			Derived Inventory Upper Inventory		
		Higher strength rock	Lower strength sedimentary rock	Evaporite rock	Higher strength rock	Lower strength sedimentary rock	Evaporite rock
Excavated Rock		5,225,000	4,820,000	4,273,000	13,800,000	11,775,000	11,366,000
Stored on site/in bunds (maximum volume)		3,589,000	3,589,000	1,172,121	3,589,000	3,589,000	2,816,121
ILW/LLW vault and HLW/SF disposal tunnel buffer/backfill requirements	Bentonite	714,000	257,000	n/a	1,946,000	731,000	n/a
	NRVB	1,000,000	1,050,000	n/a	2,300,000	2,540,000	n/a
	Excavated crushed rock	1,190,000	n/a	872,000	3,010,000	n/a	2,516,000
	MgO	n/a	n/a	144,000	n/a	n/a	356,000
Underground access (drift and/or shaft) mass backfill requirements	Excavated crushed rock	263,771	n/a	191,314	263,771	n/a	191,314
	Bentonite and sand (30:70) mix	n/a	126,660	n/a	n/a	126,660	n/a
Common services area mass backfill requirements	Excavated crushed rock	296,308	n/a	108,807	296,308	n/a	108,807
	Bentonite and sand (30:70) mix	n/a	73,749	n/a	n/a	73,749	n/a
Surplus excavated rock removal off-site		None*	1,231,000	3,100,879	6,640,921	8,186,000	8,549,879
Material imports (Bentonite, NRVB, MgO, and sand)		2,444,000	1,307,000	144,000	6,246,000	3,271,000	356,000

Please note:

Buffer/backfill materials differ for the different host rock types (refer to the assumptions in Table 2.1).

It is assumed that crushed rock backfilling requirements for the illustrative geological disposal concepts within higher strength rock and evaporite rock can be met using excavated rock from the construction of the underground facilities and therefore the quantities of crushed rock required are not included in the materials import total (refer to the excavated rock usage assumptions in Sections 2.7.4 and 2.7.6).

*For the higher strength rock Derived Inventory Reference Case excluding Pu/U all excavated higher strength rock would be stored on-site, in the form of surface bunds, and used for backfilling. Therefore none of the excavated rock would need to be transported off-site.



A summary of the transport, carbon emissions and embodied carbon estimates for the different waste inventories for each of the host rock types is provided in **Table 2.3** below. These estimates are based on the carbon footprint estimates detailed in the *Generic Carbon Footprint Analysis* ^[24]. Please note that the figures have been rounded to the nearest 100.

Table 2.3 Summary of transport and carbon estimates for the illustrative geological disposal concepts

Transport and carbon estimates	Derived Inventory Reference Case excluding Pu/U			Derived Inventory Upper Inventory		
	Higher strength rock	Lower strength sedimentary rock	Evaporite rock	Higher strength rock	Lower strength sedimentary rock	Evaporite rock
Total no. of HGVs required to transport surfaced based facilities, underground accesses (drift and/or shafts) and common services area construction materials	12,100	12,100	12,100	12,100	12,100	12,100
Total no. of HGVs required to transport ILW/LLW vault and HLW/SF disposal tunnel construction material	50,200	32,200	25,200	127,000	77,400	65,700
Total no. of HGVs required to transport ILW/LLW vault and HLW/SF disposal tunnel buffer/backfill material	75,300	46,100	6,300	186,400	111,500	15,600
CO ₂ emissions (tonnes) from transport of surplus excavated rock off-site	n/a*	47,100	118,700	254,200	313,400	327,300
CO ₂ emissions (tonnes) from transport of surfaced based facilities construction materials	4,000	4,000	4,000	4,000	4,000	4,000
CO ₂ emissions (tonnes) from transport of underground accesses (drift and/or shafts) construction materials	400	300	200	400	300	200
CO ₂ emissions (tonnes) from transport of common services area construction materials	1,200	400	400	1,200	400	400



Transport and carbon estimates		Derived Inventory Reference Case excluding Pu/U			Derived Inventory Upper Inventory		
		Higher strength rock	Lower strength sedimentary rock	Evaporite rock	Higher strength rock	Lower strength sedimentary rock	Evaporite rock
CO ₂ emissions (tonnes) from transport of ILW/LLW vault and HLW/SF disposal tunnel construction material		22,200	13,800	11,200	56,100	34,200	29,000
CO ₂ emissions (tonnes) from transport of ILW/LLW vault and HLW/SF disposal tunnel buffer/backfill material		39,000	33,200	23,100	96,600	84,400	65,400
CO ₂ emissions (tonnes) from transport of radioactive waste	Road/Rail scenario	53,400	53,400	53,400	104,800	104,800	104,800
	Sea/Road/Rail scenario	10,700	10,700	10,700	21,600	21,600	21,600

* For the higher strength rock Derived Inventory Reference Case excluding Pu/U all excavated higher strength rock would be stored on-site, in the form of surface bunds, and used for backfilling. Therefore none of the excavated rock would need to be transported off-site.



3. Methodology

3.1 Overview

This section sets out the information used to provide the context for the assessment, which has been used to inform the development of sustainability objectives against which the illustrative geological disposal concepts have been assessed. The section then sets out the assessment objectives that have been used, their relationship with the previous non-radiological assessment work (**Section 1.3.1**) and outlines how the assessment has been undertaken and the effects recorded. Lastly, the section details key uncertainties identified during the assessment that have meant the significance of some effects could not be determined, but would be expected to be the subject of further study during Stage 4 of the MRWS site selection process

3.2 Plans and programmes

As part of the assessment process, a review of 128 international, European, and national and regional plans, programmes, strategies and policies considered relevant to geological disposal has been undertaken. The review of plans and programmes is contained in **Appendix B**.

The plans and programmes follow a hierarchal order with international and European documents providing a more strategic context under which national and regional documents set more specific aims relevant to the spatial area they cover. The majority of plans and programmes relate to nuclear issues (e.g. the International Atomic Energy Agency's (IAEA) Convention on the safety of spent fuel management and on the safety of radioactive waste management), the promotion of sustainability (e.g. United Nation's World summit on sustainable development and Defra's Securing the future the UK Government sustainable development strategy), or specific environmental issues such as climate change, biodiversity, air and water quality, historic environment and waste.

The review highlighted the main aims and objectives of the documents as well as any specifically relevant targets contained within them. The findings of the review informed the development of the assessment framework by ensuring that the issues covered by the plans and programmes were adequately covered by the sustainability objectives and supporting guide questions. As the sustainability objectives have been used to assess the potential effects of the illustrative geological disposal concepts, the relationship with, and effects on, the plans and programmes have also been considered.

3.3 Baseline information

A generic overview of baseline evidence is provided in **Appendix C**. As the potential location of a GDF is unknown at present, the amount of baseline information that is relevant and can be meaningfully collected for consideration in the assessment is constrained (i.e. it would be impractical to collect project level information for



the whole country at this stage). Relevant baseline evidence has been collected for each sustainability objective. Whilst all the objectives are important, due to the activities and scale of works associated with a GDF, the key issues are anticipated to be:

- **Landscape and visual** – Many of the UK’s nuclear facilities (the sources of HAW to be emplaced in a GDF) are situated in relatively rural locations. There are a number of designated landscape areas (Areas of Outstanding Natural Beauty and National Parks) throughout the UK, some in relatively close proximity to nuclear facilities. The excavation of rock for the underground elements of a GDF would probably affect landscape and visual receptors, as would the construction of surface facilities and infrastructure.
- **Geology and soils** – A GDF would require the excavation of large volumes of rock and would result in the displacement of top-soils associated with the surface facilities and infrastructure.
- **Water** – Some river basin areas have less than good water quality status, both in terms of chemical quality and biological quality. Groundwater resources are also under pressure in some areas. Water resources may be required during the lifetime of the project and water quality may be affected by activities on site, such as through the migration of contaminants.
- **Ecology and nature conservation/biodiversity** – The UK contains a number of internationally important habitats supporting internationally important plant and animal species. Some 3% of the UK land area is designated as Ramsar sites and over 6% is designated as Special Protection Areas. In addition, there are more than 5,000 SSSIs. A GDF could have an effect on such ecological receptors.
- **Traffic and transport** – There is an established road and rail infrastructure in the UK that handles 150 billion tonne kilometres and 50 billion tonne kilometres of freight by road and rail respectively. The movement of wastes to and from a GDF during construction and operation (including radioactive wastes for emplacement), construction traffic movements and staff movements may all have an effect on the traffic and transport network.
- **Waste** – The NDA is anticipated to generate some 3,000,000m³ of waste during decommissioning. The UK Government’s policy is that a GDF is the preferred option for long-term management of some of this waste. The construction, operation and closure of a GDF may also generate (non-radioactive) wastes.

3.4 Sustainability themes and assessment objectives

It is desirable to have a level of consistency with previous assessments throughout the development of geological disposal concepts to enable stakeholders to see how progress is being made in terms of mitigating detrimental effects and enhancing positive effects. At the same time, it is important to acknowledge developments in the field of SEA.

Consequently, the themes and objectives from the work to date, (notably the Scoping Report ^[15], the SA of HLW and SF ^[17], and the SA of surface-based investigations ^[18]) along with the SEA Directive ^[10] requirements have been reviewed in light of the illustrative geological disposal concepts being assessed, current best practice and



legislation relating to SEA and SA. The results of this review are set out in **Table 3.1**. A commentary is provided highlighting the differences between the themes and objectives within the different assessments and indicating how the themes have been addressed within the generic SEA (specifically identifying the sustainability themes, for which objectives and guide questions have been developed, which are presented in **Table 3.2**).

Table 3.1 Comparison and commentary of themes covered in previous assessments with commentary on the sustainability themes used in this generic Strategic Environmental Assessment

SEA Directive theme	Scoping Report (RPS, 2005)	SA of HLW and Spent Fuel (RPS, 2008)	SA of Surface-based Investigations (Entec)	Commentary on the theme	Generic SEA theme
Biodiversity	Ecology and nature conservation	Ecology and nature conservation	Biodiversity	To highlight the wider scope of biodiversity (for example including habitats as well as individual species) it has been added to the objective heading.	The proposed theme for this Environmental and Sustainability Report is: <ul style="list-style-type: none"> Ecology and Nature Conservation / Biodiversity.
Population	Planning and policies; Land use; Socio-economics	Policies and planning; Land use	Policies and planning; Socio-economics	Socio-economics has been separated from land use to highlight the different emphasis. Socio-economics is potentially a large topic area, but will not cover health and safety issues which are covered elsewhere. Socio-economics will cover issues of economy, employment and social infrastructure (such as population changes and the impacts of such changes e.g. demand for schools, housing and recreational facilities).	The proposed themes for this Environmental and Sustainability Report are: <ul style="list-style-type: none"> Policies and Planning; and Socio-Economics.
Human Health	Health and Safety	Health effects; Community effects	Health and safety	The World Health Organisation's definition for health will be adopted for the purpose of the Generic SEA, which states that "health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" as set out in the Department of Health (2007) Draft Guidance on Health in Strategic Environmental Assessment. Health will be covered in the objective, health and well-being. Safety will be a separate topic and will summarise the work done in the safety assessments for the concepts.	The proposed themes for this Environmental and Sustainability Report are: <ul style="list-style-type: none"> Health and Well-Being; and Safety.



SEA Directive theme	Scoping Report (RPS, 2005)	SA of HLW and Spent Fuel (RPS, 2008)	SA of Surface-based Investigations (Entec)	Commentary on the theme	Generic SEA theme
Fauna	Ecology and nature conservation	Ecology and nature conservation	Biodiversity	Biodiversity has been included in the objective heading to highlight the interaction of all parts of the natural environment, habitats, wildlife, and plant species.	The proposed theme for this Environmental and Sustainability Report is: <ul style="list-style-type: none"> Ecology and Nature Conservation / Biodiversity.
Flora	Ecology and nature conservation	Ecology and nature conservation	Biodiversity	Biodiversity has been included in the objective heading to highlight the interaction of all parts of the natural environment, habitats, wildlife, and plant species.	The proposed theme for this Environmental and Sustainability Report is: <ul style="list-style-type: none"> Ecology and Nature Conservation / Biodiversity.
Soil	Geology and soils	Geology and soils	Geology and soils	No change is proposed to this topic.	The proposed theme for this Environmental and Sustainability Report is: <ul style="list-style-type: none"> Geology and Soils.
Water	Water resources	Water resources	Water	Water has been broadened to consider quality as well as resource use.	The proposed theme for this Environmental and Sustainability Report is: <ul style="list-style-type: none"> Water.
Air	Air and climate	Air quality and climate	Air quality	It is considered to compare more favourably with the SEA Directive requirements by separating air and climate into separate topics.	The proposed theme for this Environmental and Sustainability Report is: <ul style="list-style-type: none"> Air Quality.
Climatic Factors	Air and climate	Air quality and climate	Climate	Climate is considered separately to align with the SEA Directive requirements and general best practice. Climate will also specifically consider energy requirements.	The proposed theme for this Environmental and Sustainability Report is: <ul style="list-style-type: none"> Climate Change.



SEA Directive theme	Scoping Report (RPS, 2005)	SA of HLW and Spent Fuel (RPS, 2008)	SA of Surface-based Investigations (Entec)	Commentary on the theme	Generic SEA theme
Material Assets	Noise and vibration; Traffic and transport; Resource use, services and utilities	Traffic and transport; Noise and vibration; Waste, Resource use, utilities and services	Traffic and transport; Noise and vibration; Land use; Waste; Resource use, utilities and services	Land use is now a separate objective. Waste is also considered as a separate objective rather than being combined with resource use, utilities and services which focus specifically on the consumption of physical materials, such as aggregates, concrete, metal etc. The volume of waste generated may be a significant differentiating factor between the designs for the facility for different geological locations. As such, having a separate objective will help identify the effects on waste in more detail. No changes are proposed to traffic and transport.	The proposed themes for this Environmental and Sustainability Report are: <ul style="list-style-type: none"> ▪ Traffic and Transport; ▪ Noise and Vibration; ▪ Land Use; ▪ Waste; and ▪ Resource Use, Utilities and Services.
Cultural Heritage (including architectural and archaeological heritage)	Cultural heritage	Cultural heritage	Cultural heritage	No amendments have been proposed to cultural heritage. It is recognised that at the generic level it has generally been found that the lack of specific site information has resulted in effects generally being uncertain. However, it is considered best practice to continue to identify the potential activities that could result in effects, and it will be applicable for the Stage 4 methodology.	The proposed theme for this Environmental and Sustainability Report is: <ul style="list-style-type: none"> ▪ Cultural Heritage.
Landscape	Landscape, townscape and visual effects	Landscape / townscape and visual effects	Landscape and visual	The objective heading has been shortened but townscape is still considered and is highlighted by a specific guide question.	The proposed theme for this Environmental and Sustainability Report is: <ul style="list-style-type: none"> ▪ Landscape and Visual.

Building on the topics set out in the previous studies, the analysis of relevant plans and programmes and review of baseline information, sustainability objectives have been developed for each of the generic SEA themes identified in **Table 3.1**. The contribution towards or away from the objective based on consideration of the potential effects is then used to inform the assessment. The identification, characterisation and assessment of effects are usually informed by qualitative and quantitative information where available. The completion of the assessment against the sustainability objectives is also supported by the use of ‘guide questions’ that ensure full consideration is given to specific issues and the various factors that can influence an objective. Guide questions help to provide the detailed assessment framework. It is not intended that they be answered individually or consistently, rather that they serve as a guide to the types of issues that may need to be considered to ensure a comprehensive assessment of



the potential effects. For example, the guide questions for sustainability theme 3 (Cultural Heritage), prompt consideration of surface and subsurface archaeology, listed buildings and traditional activities.

The objectives and guide questions that have been used to assess the illustrative geological disposal concepts are listed in **Table 3.2**, along with the corresponding topics identified in the SEA Directive ^[10].

Table 3.2 Sustainability themes, objectives and guide questions

Sustainability theme and objective	Guide questions	SEA topic
1. Policies and Planning: Comply with Government policy and meet the requirements of applicable international and national legislation.	<ul style="list-style-type: none"> ▪ Will the activities contribute towards fulfilling Government policies on sustainable development? ▪ Will the activities follow guidance set out in the national policy framework for development (i.e. Planning Policy Statement series)? ▪ Will the activities achieve the necessary requirements set out in international legislation and policy (i.e. EU directive)? 	Material assets
2. Landscape and Visual: Maintain and enhance the quality and character of the landscape and townscape, and minimise visual effects and light pollution.	<ul style="list-style-type: none"> ▪ How extensive will the land take requirements be? ▪ Will there be an introduction of new landscape and visual features or elements? 	Landscape
3. Cultural Heritage: Minimise detrimental effects on heritage assets and seek to enhance the recording, conservation and preservation of assets and their settings.	<ul style="list-style-type: none"> ▪ Will there be the potential to affect subsurface archaeology? ▪ Will there be the potential to affect surface archaeology? ▪ Will there be the potential to affect the setting of listed buildings? ▪ Will there be the potential to affect traditional activities? 	Cultural heritage (including architectural and archaeological heritage)
4. Geology and Soils: Reduce contamination and safeguard soil quality and quantity. Where land is affected by contamination, remediate to a condition suitable for use.	<ul style="list-style-type: none"> ▪ Will there be a loss of soil reserves? ▪ Will there be a deterioration of soil quality? ▪ Will there be a change in the soil erosion regime? ▪ Will there be a change in the geological erosion regime? 	Soil
5. Water: Maintain and enhance water quality, minimise abstraction to conserve resources at sustainable levels. Reduce the risk of flooding.	<ul style="list-style-type: none"> ▪ Will there be an increase/decrease in water abstraction? ▪ Will there be a change in the quality of surface water or ground water? ▪ Will there be a potential to increase the levels of flood risk? 	Water
6. Ecology and Nature Conservation / Biodiversity: Protect, enhance and promote natural biodiversity and habitats and avoid their fragmentation.	<ul style="list-style-type: none"> ▪ Will the activities have an effect on wildlife or habitats? ▪ Will the need for additional infrastructure lead to a fragmentation of habitats or affect wildlife? 	Biodiversity, Flora, Fauna
7. Traffic and Transport: Reduce the need to travel, particularly by car or lorry, and reduce the levels of road congestion, maintaining and improving, where appropriate, travel facilities and choices.	<ul style="list-style-type: none"> ▪ Will there be a change in the sources, levels and types of road traffic generated? ▪ Will there be a change in the sources, levels and types of rail traffic? ▪ Will there be a change in the sources, levels and types of maritime traffic? ▪ Will there be any effects on the national transport network? ▪ Will there be any affects from additional transport infrastructure? 	Material assets



Sustainability theme and objective	Guide questions	SEA topic
8. Air Quality: Minimise the emission of pollutants and enhance air quality to exceed statutory levels where possible.	<ul style="list-style-type: none"> ▪ Will there be a change in the key types of and sources of pollutants emitted? ▪ Will there be a change in the key sources of dust generated? 	Air
9. Climate Change: Minimise greenhouse gas emission, encourage adaptability to climate change and encourage the use of low carbon technology. Increase the proportion of energy generated from renewable sources.	<ul style="list-style-type: none"> ▪ Will there be a change in emissions of greenhouse gases? ▪ To what extent will the potential consequences of climate change be mitigated against? ▪ Will there be a change in the levels of energy consumed? ▪ Will energy be supplied from renewable sources? 	Climatic factors
10. Noise and Vibration: Minimise noise pollution and the effects of vibration.	<ul style="list-style-type: none"> ▪ Will there be a change in the sources and levels of noise generated? ▪ Will there be a change in the sources and levels of vibration generated? 	Material assets
11. Land Use: Minimise consumption of, and reduce damage to, undeveloped land and agricultural holdings through re-use of previously developed land and existing buildings.	<ul style="list-style-type: none"> ▪ Will land be required? ▪ Will there be a change in existing land use patterns? 	Material assets, Landscape
12. Socio-economics: Maximise access for all to opportunities for rewarding employment, education and skills training. Encourage a strong, diverse and stable economy.	<ul style="list-style-type: none"> ▪ Will there be a change in employment opportunities? ▪ Will there be a change in the employment profile? ▪ Will there be a change in the demographic profile? ▪ Will there be a change in the demand for housing? ▪ Will there be a change in the level of qualifications and skills available in the area? ▪ Will there be a change in the use of recreational facilities? ▪ Will there be a change in the quality of life? ▪ Will there be a change in the levels of deprivation? ▪ Will there be a change in the demand for General Practitioners, dentists and schools etc? 	Population, Material assets
13. Health and Well-being: Protect and promote human health and well-being through healthy lifestyles and healthcare provision. Create conditions to improve health and reduce health inequalities.	<ul style="list-style-type: none"> ▪ Will there be a change in the levels of health of the population? ▪ Will there be a change in the levels of health of workers or contractors? ▪ Will there be a change in the levels of crime? ▪ Will there be a change in the fear of crime? ▪ Will there be a change in well-being and health inequalities? 	Human health, Population
14. Safety: Promote safe working practices that minimise the risk of accidents or hazards to workers, contractors or the local community.	<ul style="list-style-type: none"> ▪ Will there be a change in the types of hazards associated with the activities? ▪ Will there be a change in the accident rates on site? ▪ Will there be a change in the risk to workers or contractors? ▪ Will there be a change in the transport accidents rates? ▪ Will there be a change in the risk to the local population? 	Human health, Population



Sustainability theme and objective	Guide questions	SEA topic
15. Waste: Minimise the generation of waste and promote the application and adherence to the waste management hierarchy.	<ul style="list-style-type: none"> ▪ Will there be a change in the amount of sewage to be disposed? ▪ Will there be a change in the type and levels of waste generated? ▪ Will waste be managed in accordance with the waste hierarchy (reduction, re-use, recycling and compositing, recovery of energy, and disposal)? 	Material assets
16. Resource Use, Utilities and Services: Encourage and promote the efficient use of resources (materials, aggregates, metal).	<ul style="list-style-type: none"> ▪ Will materials/equipment be sourced locally? ▪ Will there be a change in the quantities of resource use? ▪ Will materials be required for additional infrastructure? 	Material assets

3.5 Assessing the sustainability effects

The assessment considers the extent to which implementation of the illustrative geological disposal concepts would contribute towards the achievement of the objectives, relative to the baseline situation (refer to **Section 3.3** and **Appendix C**). It considers each phase of implementation and the different host rock types and waste inventories as outlined in **Section 2**.

A six point qualitative scoring system has been used to assess the effects of the illustrative geological disposal concepts which provides an indication of the magnitude of the effects predicted (**Table 3.3**). The qualitative scoring system has been used in the summary for each implementation phase presented in **Section 4**, in the headline issues sections of the detailed assessment (in **Appendix D**) and in the cumulative summary matrix (**Table 4.11**).

Table 3.3 Qualitative scoring system

Score	Description	Symbol
Major positive effect	The illustrative geological disposal concept contributes significantly to the achievement of the objective,	++
Minor positive effect	The illustrative geological disposal concept contributes to the achievement of the objective but not significantly.	+
Neutral / negligible	The illustrative geological disposal concept does not have any positive or negative effects on the achievement of the objective.	0
Minor negative effect	The illustrative geological disposal concept detracts from the achievement of the objective but not significantly	-
Major negative effect	The illustrative geological disposal concept detracts significantly from the achievement of the objective.	--



Score	Description	Symbol
Uncertain	The illustrative geological disposal concept has an uncertain relationship with the objective or the relationship is dependant on the way in which the issue is managed. In addition, insufficient information may be available to enable an assessment to be made.	?

Assessments are presented in matrix form, structured and ordered according to the sustainability themes that cover each objective.

For each implementation phase, the assessment of effects and the proposed mitigation/enhancements have been presented in detail for the higher strength rock type, and it is only where the other host rock types vary from the findings of this assessment that the effects are identified, characterised and assessed, and further mitigation measures/enhancements are noted.

For each theme, the following information has been presented in the assessment matrix:

- The assessment of effects;
- Assumptions and uncertainties;
- Proposed mitigation/enhancements;
- A summary of information requirements;
- Any significant effects that would occur for other rock types; and
- Headline issues that provide a scored indication of the contribution towards the objective and the key effects that are anticipated to affect such a contribution.

3.6 Uncertainties

At this stage there are inevitable uncertainties about the location, siting and design of a GDF. The following uncertainties have been identified prior to completing the assessment of the illustrative geological disposal concepts for the different host rock types as they are dependent on site location and more detailed design information, which are not known at this stage:

- The cultural heritage value of the site and its surrounds.
- The location of the site in relation to water, floodplains and flood sensitive areas.
- The biodiversity value of the site and its surrounds.
- The proposed transport method for construction materials, machinery and any construction wastes.



- The location of the site in relation to strategic and local road networks, and sensitive receptors such as houses and schools.
- The local air quality of the site and its surrounds.
- The land use value of the site and its surrounds.
- The nature of the local economy and employment.
- The nature, duration and value of any community benefits package agreed as part of the implementation of a GDF.
- The quantities of waste arising and proposed waste management methods (e.g. the extent of re-use and recycling).
- The quantities of material required for backfilling the remaining underground roadways and facilities are not available at this stage. Estimates are provided for certain areas. Consequently it is unknown whether crushed rock backfill requirements for this purpose could be met on site using the excavated rock from the construction of the underground facilities.
- The quantities of resources, utilities and services required is not available at this stage.
- The potential effects of climate change on the environment (particularly in relation to water resources and quality, flooding, erosion, biodiversity and socio-economics) are uncertain at this stage.

Due to these uncertainties, it has not been possible to assess the illustrative geological disposal concepts against all of the relevant guide questions at this stage, since there is not enough information to make a meaningful assessment. Where guide questions have not been addressed, or the effect is uncertain due to the lack of site-specific information, these will be the subject of further study during Stage 4 of the MRWS site selection process and future assessments of geological disposal concepts. Taking this into account, it should be noted that clarification of the uncertainties is likely to have an effect on the final outcome of the assessment.

The uncertainties regarding the location of a GDF also make considering the cumulative effects of implementation, in conjunction with other nationally or regionally significant infrastructure plans or programmes, difficult. A range of nationally significant infrastructure schemes is anticipated in the draft National Policy Statements (NPSs) being developed for energy, waste, transport and water infrastructure; however, many of the draft NPSs are non locational and generic in nature. Exceptions to this include the new nuclear power generation NPS ^[25], which identifies 11 potential sites that could be suitable for the deployment of new nuclear power stations by the end of 2025. The combination of a GDF in proximity to a new nuclear power station may give rise to a number of cumulative effects, such as increases in traffic movements, disturbance to biodiversity and fragmentation of habitats, changes to the landscape as well as changes to noise, air quality and water quality. However, the magnitude and significance of these cumulative effects would be dependent on the location of receptors and the projects, the design and scale of the proposals, and the timing of works.



3.7 **When the assessment was undertaken and by whom**

The assessment of the illustrative geological disposal concepts was undertaken between summer 2009 and autumn 2010 by sustainability and technical consultants at Entec with input from the NDA.



4. The assessment of effects

4.1 Scope of the assessment

The generic SEA has assessed the potential environmental, social and economic effects of illustrative geological disposal concepts for three host rock types (higher strength rock, lower strength sedimentary rock and evaporite rock) outlined in the NDA report of Generic disposal facility designs^[8] (refer to **Section 2**).

The following implementation phases have been assessed for each host rock type:

- Surface-based site investigation;
- Construction;
- Operation; and
- Closure and post-closure.

For the purposes of the generic SEA, the effects of disposing of the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory waste volumes within an illustrative geological disposal concept for each host rock has been considered as, for planning purposes, these have been assumed to represent reasonable lower and upper size limits for a facility. However, it is recognised that these scenarios are not bounding and the inventory for disposal will ultimately be decided by Government in consultation with potential host communities. The mid-level waste inventory, the Derived Inventory Reference Case, (which includes Pu and U) is not considered further in this assessment.

The detailed assessments are presented in **Appendix D** and the findings of each is summarised in the following sections (**Section 4.2 to Section 4.5**) for each implementation phase.

The cumulative effects of the different implementation phases are considered in the summary section (**Section 4.6** and **Table 4.11**).

Key measures that could be used to address the potential adverse effects identified or to enhance the potential positive effects associated with GDF implementation are detailed in **Section 4.7**.



4.2 Surface-based site investigations

Table 4.1 presents the summary of the effects of the surface-based site investigation phase.

Table 4.1 Summary of the effects of the surface-based site investigation phase

Sustainability theme	Summary of the key issues	Score
1. Policies and Planning	<p>The surface-based site investigations would help to ensure the selection of an appropriate site for the development of a GDF, thus contributing positively towards fulfilling international and national policy and legislative commitments for the safe long-term management of radioactive wastes.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	+
2. Landscape and Visual	<p>Drilling campaigns could result in the fragmentation or loss of key landscape elements or features, which could have a negative effect on landscape character. The total land take for 16 deep borehole drilling pads is estimated to be around 1.2km² per site, along with additional land take for the construction of access tracks and the central office compound, and for shallow borehole drilling campaigns.</p> <p>The drilling campaigns could also have a negative visual effect from the introduction of new elements into existing views, particularly the erection of the drilling rigs at borehole locations, which are assumed to be of a similar scale to a large pylon or large lorry mounted crane. In addition, lighting operating on a 24 hour basis could have a visual impact, with light pollution effects.</p> <p>However, any landscape and visual effects arising from the drilling campaigns would affect relatively small areas and would be temporary in nature (lasting the duration of the drilling campaigns). It is assumed that the land would be restored to its pre-programme condition following completion of the drilling campaigns.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	-
3. Cultural Heritage	<p>Drilling campaigns, particularly the construction of the borehole drilling pads, access roads and support infrastructure, could result in the direct loss of or damage to visible above ground cultural historic or archaeological features and landscapes within the development footprint. The introduction of new elements into existing views could also have a negative effect on the setting/amenity of above ground historic or archaeological features and landscapes.</p> <p>Activities associated with drilling could result in the direct loss of, or cause damage to, subsurface or buried archaeological remains. However, generally the potential for archaeology below a depth of 1-2m is considered to be limited (with the exception of historic mine workings), with any remains typically found within the soils above the drift geology. The greatest potential for effects would therefore be during construction works such as stripping topsoil, site levelling, digging foundations and piling, and during shallow surface investigations such as trial pitting and trenching, and shallow borehole drilling.</p> <p>At this stage no sites have been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the surface-based site investigations to any cultural heritage and archaeological sites, features and landscapes, their current condition and sensitivity, and the level of disturbance or loss.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	?
4. Geology and Soils	<p>There would be some loss of topsoil and subsoil during the construction of the borehole drilling pads, support infrastructure and access roads. However, this would be reinstated following completion of the drilling campaigns. The reinstatement of soils could also have a negative effect on soil quality, although this could be sufficiently mitigated following best practice guidance on soil handling and storage.</p> <p>Drilling campaign activities could introduce some low level contamination to soils (including, for example, silty water, drill fluid and oil spillages). However, assuming that the sites would be greenfield it is unlikely that any ground contamination from previous land uses would be encountered.</p> <p><i>(continued)</i></p>	-



Sustainability theme	Summary of the key issues	Score
4. Geology and Soils	<p>The drilling campaigns would result in the removal of small volumes of rock (between 75 and 100m³ of rock per year), which would be taken away for testing and analysis. Depending on the level of contamination, once no longer required the drill cuttings would be disposed of to landfill or as hazardous waste.</p> <p>Borehole drilling campaigns could affect sites of recognised importance for their geological value (e.g. SSSI or RIGS), although the designation is typically determined by the surface geology rather than the deeper stratigraphy. Such effects would be site specific and are therefore uncertain at this stage.</p> <p>Depending on the site location, drilling campaigns within the higher strength rock and evaporite rock could sterilise minerals (where the development takes place on, or close to minerals deposits), rendering them incapable of being extracted, at minimum for the duration of the drilling campaigns. Any drilling campaigns for lower strength sedimentary rock, however, would be unlikely to have an effect on minerals, due to its low commercial value.</p> <p>Borehole drilling could create new rock fractures (or increase the existing fracture network) which in turn could reduce the mechanical strength of the rock, increase its hydraulic permeability and/or create local, new flow pathways for water. The latter has the potential to adversely affect rock chemistry locally (i.e. weathering). However, the drilling methodologies would be chosen to minimise these impacts as such fracturing would have a detrimental affect on the quality of the data acquired from investigations. It is considered that any residual effects would therefore be negligible and would be spatially limited to the immediate vicinity of the drilling activities.</p> <p>It is assumed that the site investigations would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	-
5. Water	<p>Water would be required throughout the drilling campaigns for use in construction such as dust suppression, drilling fluid and cooling equipment, and for potable purposes such as drinking water and canteen use, as well as toilet and washing facilities. The anticipated increase in water used is estimated to be approximately 1,000m³ per borehole for the borehole drilling and 16 litres per employee per day. Water would also be required during post completion testing, involving long-term low rate pumping tests operating 24 hours a day, 7 days a week, across a network of boreholes.</p> <p>Depending on local water resource availability and demand at the site(s), there would be the potential for water use to affect the availability of water, or for environmental flow targets to be affected.</p> <p>Activities associated with borehole construction would generate several sources of water requiring discharge, which could affect the water quality and/or rate of flows of receiving waters. Surface run-off could contain contaminants released through spillage of materials used during the drilling campaigns such as chemicals, oils and fuels.</p> <p>Drilling activities may also introduce contaminants to groundwater sources (e.g. drilling fluid), and water used as drilling fluid is likely to have a high sediment load, which could affect water quality if discharged untreated. However, it is assumed that any water would be treated prior to discharge, therefore reducing the potential for significant effects on water quality.</p> <p>Borehole installation could have localised effects on groundwater flow patterns in the area of the borehole, acting as a barrier where boreholes are lined with an impermeable lining or where equipment is present within the boreholes. Borehole drilling may also produce fractures in the rock which act as conduits for groundwater. However, any effects would be localised and only for the duration of the drilling campaigns.</p> <p>The construction of the borehole drilling pads, support infrastructure and access roads may increase flood risk, due to changes to surface drainage patterns and the increase in impermeable surface areas, affecting surface run-off rates and flow pathways.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	-
6. Biodiversity, Flora and Fauna	<p>Drilling campaign activities could result in the loss or fragmentation of habitat. Effects could be direct (e.g. loss to hard engineering such as the drilling pads or access roads) or indirect (e.g. changes in character due to alterations in drainage patterns and deposition of pollutants).</p> <p>The drilling campaigns may also lead to disturbance/displacement of wildlife (fauna) as a result of noise, human presence and light pollution, with the potential for effects on breeding success and survival.</p> <p><i>(continued)</i></p>	?



Sustainability theme	Summary of the key issues	Score
6. Biodiversity, Flora and Fauna	<p>The accidental release of substances such as diesel and drilling fluid, silt laden run-off, and the deposition of pollutants associated with transport movements could also negatively affect biodiversity.</p> <p>At this stage no sites have been selected and subsequently the effect is uncertain. The potential for effects would depend on the biodiversity value of the sites and their surrounds, the sensitivity of any habitat/species present and the level of habitat disturbance or loss.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	?
7. Traffic and Transport	<p>There would be an increase in traffic movements on the local road network throughout the drilling campaigns, associated with site staff, HGVs, a range of heavy plant construction vehicles and deliveries. It is estimated there would be up to 10 HGV movements per week to each drilling location during the drilling period of 6 months (260 movements in total).</p> <p>Traffic and transport effects that could be considered as potentially significant include severance to pedestrians/cyclists induced by the flow of vehicles along a road, driver delay, loss of pedestrian/cyclist amenity and safety implications. The significance of any effects would depend on the location of the sites, traffic generation, the sensitivity of the local highway network and traffic routing.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	-
8. Air Quality	<p>There would be the potential for exhaust emissions from vehicle movements, construction plant and generators associated with surface-based site investigations to lead to a decrease in local air quality. However, given the small number of HGV movements (5 to 10 per week) and relatively small scale nature of the operations any decrease in local air quality is unlikely to be significant.</p> <p>Any dust generated during surface-based site investigations (e.g. during earthworks, soil stripping, storages of materials and drilling), could also have an effect on local air quality if unmanaged. Dust or pollutant emissions could potentially be noticeable to nearby sensitive receptors (e.g. residents) where up to 3 drilling pads are within 1km of each other. Notwithstanding this, if emissions are likely to be spread across the area covered by site investigation work then any emissions could be sufficiently dispersed to prevent noticeable concentrations. This would depend on the existing air quality in the area prior to construction.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	-
9. Climate Change	<p>The emission of CO₂ from vehicle movements, any use of diesel generators and the energy used in infrastructure (including the embodied energy within the construction materials used) would contribute to climate change. The construction and operation of 20 deep boreholes is estimated to generate in the region of 2,100 tonnes of CO₂ in total.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	-
10. Noise and Vibration	<p>The site investigation works would result in perceptible increases in noise, particularly from drilling rigs, diesel generators (if applicable) and works traffic. Drilling activities would generate both continuous background noise on a 24 hour basis and intermittent noise levels during pipe handling.</p> <p>The use of explosives and vibroseis trucks for seismic surveys would also generate noise and vibrations, although the vibrations would be of low amplitude and of short duration and therefore the effect would probably be negligible. Similarly, there is anticipated to be an increase in noise during the aerial surveys due to the low altitude of the aircraft (50-100m), although this would be for a very short duration and would only affect a localised area.</p> <p>Activities associated with borehole construction, such as drilling and HGV movements, may also have vibration effects. However, such effects would be difficult to quantify until the ground conditions are known.</p> <p>Depending on the proximity of sensitive receptors to the works, noise and vibrations associated with site investigation works could have an effect on sensitive receptors (e.g. occupants of residential buildings, community and recreational facilities).</p> <p><i>(continued)</i></p>	?



Sustainability theme	Summary of the key issues	Score
10. Noise and Vibration	<p>At this stage no sites have been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the sites and site investigation works to sensitive receptors and the level and extent of noise and vibration generated.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	?
11. Land Use	<p>The drilling campaigns would involve land take; it has been assumed for planning purposes that deep borehole construction would be undertaken within two areas, each of around 50km². The total land take is estimated to be around 0.16km² within each area for 16 deep borehole drilling pads. Further land take within the area would also be required for the construction of access tracks and support facilities, and for shallow borehole drilling campaigns. It is assumed that the remaining land within each area would remain in its existing use.</p> <p>Assuming that the sites are greenfield, there would be the potential for land take to have a negative effect throughout the duration of the drilling campaigns, particularly where there may be a consequential loss or severance of agricultural land or community/recreational land. Following completion of the surface-based site investigations, where an area is not taken forward, assuming the land would be restored to its pre-programme condition, the long-term effect on land use would be negligible. However, in the case of the area(s) chosen to be taken forward, part of the area could be retained for construction of a GDF, in which case any effects from land take would remain.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	-
12. Socio-economics	<p>The surface-based site investigations would generate a number of employment opportunities, a proportion of which may be suitable for the local workforce, and would support local services (e.g. garages, shops, restaurants and accommodation). In total, for the duration of the site investigation works it is estimated that, on average, 570 people per year could be employed, of which an estimated 491 people would be directly involved in the site investigation works. Although the majority of these jobs may be available to and taken by local contractors and individuals, they would only be temporary.</p>	+
	<p>There would be the potential for site investigation works to have a negative effect on the quality of life of local populations (e.g. associated with traffic on the road network, noise, vibration and air quality impacts from works and traffic). Drilling campaigns could also affect the viability of businesses (e.g. effects in productivity due to disturbance to staff from noisy activities).</p> <p>At this stage no sites have been selected and subsequently the potential for effects on quality of life and business productivity is uncertain. The potential for effects would depend on the proximity of the works to sensitive receptors and the level and extent of any disturbance.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	?
13. Health and Well-Being	<p>Drilling campaigns could have a negative effect on the health and well-being of local populations (e.g. disturbance from noise and vibrations, and air quality effects from works and traffic). There may also be some temporary noise disturbance to residents from aircraft during low level aerial surveys.</p> <p>Site investigation works may be subject to protest action from opposition groups and local communities, which could potentially increase people's fear of crime due to an influx of a large number of people into a localised area.</p> <p>At this stage no sites have been selected and subsequently the effects on health and well-being are uncertain. The potential for effects depends on the proximity of the works to sensitive receptors and the extent of any disturbance. At this stage it is uncertain to what extent there would be active opposition to the work.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	?



Sustainability theme	Summary of the key issues	Score
14. Safety	<p>Surface-based site investigations present a risk to human health and safety. Hazards to the on-site workforce and visitors include collision/impact hazards (e.g. involving plant/vehicles and personnel); exposure to substances hazardous to health (e.g. contact with cement and dusts); entrapment; electrical hazards; and occupational hazards such as working at height and manual handling.</p> <p>The surface-based site investigations are unlikely to present a significant risk to the public (i.e. local communities) provided access to work areas is restricted and the relevant health and safety procedures are in place. However, there is the potential for an increased risk of road traffic accidents associated with any increase in traffic movements arising from the works.</p> <p>Although there are many potential risks associated with surface-based site investigations, it is assumed that any risks would have been identified and managed through compliance with health and safety legislation and risk management procedures. The staff working on site would be professionals and would be unlikely to experience any greater risk to safety than at other work locations. Members of the public would not be allowed on site. As such, the potential effects are not considered to be significant.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	-
15. Waste	<p>A range of wastes would be generated during surface-based site investigations, particularly the drilling campaigns. If the wastes arising are averaged out as 20 boreholes of 25,000m of drilling over a 6 year period it is estimated that between 75 to 100m³ of drill cuttings, 250 to 300m³ of drilling fluid, 300 to 350m³ of test water, and 400 to 500m³ of construction waste would be generated per year.</p> <p>In addition, it is anticipated that there would be a small amount of waste generated during the drilling process from waste oil, greases and solvents for the machinery at each drilling pad, along with containers and packaging (timber pallets, casing thread protectors for drill components and excess cement from casing installations), from fuels, oils and cement.</p> <p>There would also be some general office waste such as paper, organic canteen waste, packaging and possibly some electrical waste from the replacement and upgrades of computers, printers or other electrical products. The average waste figures for UK Government indicate that approximately 0.45 tonnes of waste are generated per employee. Consequently, it is estimated that some 67.5 tonnes may be generated by the office accommodation per year.</p> <p>Depending on their type, wastes may be sent to landfill, recycled or re-used, for example, as landscaping or as aggregates for construction projects. Some of the waste (some drilling fluid, small amounts of laboratory waste) may be treated as hazardous waste and would need to adhere to relevant waste regulations.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	-
16. Resource Use, Utilities and Services	<p>A range of resources, utilities and services would be required throughout the surface-based site investigations, particularly during the drilling campaigns for the construction of the drilling pads, support infrastructure and access roads. Key utilities and services required include electricity, water supplies and communication systems. Diesel generators may be used as the primary source of electricity at the drilling pads if suitable mains connections do not exist, or the local mains supply is deemed to be unreliable.</p> <p>It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>	-



4.3 Construction

Table 4.2 presents the summary of the effects of the construction phase.

Table 4.2 Summary of the effects of the construction phase

Sustainability Theme	Summary of the Key Issues	Score
1. Policies and Planning	<p>Construction of a GDF would fulfil a number of policy and legislative commitments at international and national level; according with the principles of the IAEA Action Plan, the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, and meeting UK Government requirements for the long-term management of radioactive wastes in accordance with the MRWS programme.</p> <p>However, the construction of a GDF could be associated with a significant carbon footprint, which if not matched by corresponding reductions elsewhere in the UK economy could detract from the UK meeting its obligations under the Climate Change Act 2008 (refer to Sustainability Theme 9).</p> <p>There would probably not be any significant differences in effects between the different host rock types and waste inventories, as all of the host rock types would meet policy requirements.</p>	+
2. Landscape and Visual	<p>Surface construction activities could result in the fragmentation or loss of key landscape elements, and significantly alter landscape character, particularly the construction of the surface facilities, and the storage of excavated rock on site, either in surface bunds or within a dedicated storage area. Improvements to, or the construction of, new rail and/or road infrastructure to the site could also have a negative effect on landscape character and visual amenity. Surface construction could also have a negative visual effect through the introduction of new visual elements, and from lighting operating on a 24 hour basis on site.</p> <p>In addition, there is the potential for any surplus excavated rock removed off-site from the construction of the underground facilities to have a negative landscape and visual effect. However, this would depend on its end use and location, and therefore the potential for effects is uncertain at this stage.</p> <p>There would probably not be any significant difference in potential landscape and visual effects between the different waste inventories and host rock types, as the surface site area is assumed to be the same (approximately 1.1km² for each of the host rock types, assuming that the surface site area for evaporite rock includes surface screening bunds).</p> <p>Notwithstanding this, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated evaporite rock would be stored on site (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the higher strength rock and lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for evaporite rock.</p> <p>The potential landscape and visual effect of surface bunds could be positive or negative. Such features would reduce visibility of the site, although depending on their scale and nature surface bunds could also have a negative effect (i.e. where the surface bunds are extensive and may not be well integrated with the landscape surrounding the site).</p> <p>The potential landscape and visual effect of the construction of a GDF would be greater than that of the surface-based site investigations. However, at this stage no site has been selected and therefore the significance of any negative effects is currently unknown.</p>	-



Sustainability Theme	Summary of the Key Issues	Score
<p>3. Cultural Heritage</p>	<p>There would be the potential for surface construction activities to result in the direct loss of or damage to visible above ground cultural historic or archaeological features within the development footprint of the surface site area (assumed to be approximately 1.1km² for each of the host rock types) or to have a negative effect on the setting and amenity of above ground historic or archaeological features and landscapes within the vicinity.</p> <p>Construction activities (e.g. stripping topsoil, site levelling, digging foundations, piling works, drilling and excavations) could also result in the direct loss of, or cause damage to, subsurface or buried archaeological remains. This may include known archaeology (such as designated or recorded sites) or previously unknown archaeology.</p> <p>Generally, there would be limited potential for archaeology below a depth of 1-2m (with the exception of historic mine workings), with any remains typically found within the soils above the drift geology. The greatest potential would therefore be during construction of the surface facilities and infrastructure, and excavations into the soils above the drift geology.</p> <p>Excavation activities at a depth of greater than 2m would be unlikely to affect subsurface or buried archaeological remains and there would be limited potential for archaeological remains within the host rock (assuming there are no historic mine workings). However, it is also recognised that there would be the potential for additional discoveries to be made during construction activities.</p> <p>There would be the potential for indirect damage to subsurface or buried archaeological remains due to contamination, ground consolidation, or changes to the hydrological regime. However, as noted above there would be limited potential for archaeology within the host rock and the potential for significant ingress is considered to be low.</p> <p>There would be the potential for pollution from engine exhausts and vibration associated with any increase in rail traffic or road traffic (particularly HGVs in the case of road traffic) (refer to Sustainability Theme 7, Traffic and Transport) to have a negative effect on historic or archaeological features (e.g. listed buildings) by accelerating corrosion/weathering.</p> <p>There would probably not be any significant difference in potential effects on visible above ground cultural heritage or archaeological features between the different waste inventories and host rock types, as the surface site area is assumed to be the same. Notwithstanding this, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site in the case of evaporite rock (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the higher and lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for evaporite rock.</p> <p>There would probably not be any significant difference in potential effects on subsurface or buried archaeological remains between the different host rock types, as excavation activities at a depth greater than 2m would be unlikely to affect subsurface or buried archaeological remains.</p> <p>At this stage, no sites have been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of works to any cultural heritage and archaeological sites, features and landscapes, the condition and sensitivity of the site/feature/landscape affected and the level of disturbance or loss.</p>	<p style="text-align: center;">?</p>
<p>4. Geology and Soils</p>	<p>Surface construction activities (e.g. site clearance and levelling) would result in a loss of soil and sedimentary rock within the footprint of surface facilities/infrastructure (buildings, hardstanding and access roads).</p> <p>Assuming that a GDF would be located on a greenfield site, it is unlikely that any ground contamination from previous land uses would be encountered. However, a number of construction activities could introduce levels of contamination (e.g. silty water, drill fluid and oil spillages).</p> <p>There would probably not be any significant difference in potential effects on soils associated with surface construction activities between the different waste inventories and host rock types, as the surface site area is assumed to be the same (approximately 1.1km², assuming that the surface site area for evaporite rock includes surface screening bunds).</p> <p><i>(continued)</i></p>	<p style="text-align: center;">-</p>



Sustainability Theme	Summary of the Key Issues	Score
4. Geology and Soils	<p>However, a smaller volume of excavated rock would be stored on site in the case of evaporite rock (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the higher strength rock and lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for evaporite rock, reducing potential effects on soils. Notwithstanding this, as the excavated evaporite rock would not be suitable for surface bunding, any surface screening bunds required within the site would need to be created using spoil and imported material as required.</p>	-
	<p>The construction of a GDF would require large volumes of rock to be excavated, as follows:</p> <ul style="list-style-type: none"> ▪ Approximately 5,225,000m³ of higher strength rock to be excavated for the Derived Inventory Reference Case excluding Pu/U (4.3km² underground footprint) and 13,800,000m³ for the Derived Inventory Upper Inventory (9.8km² underground footprint); ▪ Approximately 4,820,000m³ of lower strength sedimentary rock to be excavated for the Derived Inventory Reference Case excluding Pu/U (7.8km² underground footprint) and 11,775,000m³ for the Derived Inventory Upper Inventory (19.5km² underground footprint); and ▪ Approximately 4,273,000m³ of evaporite rock to be excavated for the Derived Inventory Reference Case excluding Pu/U (6.5km² underground footprint) and 11,366,000m³ for the Derived Inventory Upper Inventory (18.4km² underground footprint). <p>Given the footprint of the underground facility and the volume of rock excavated, the construction of a GDF could affect sites of recognised importance for their geological value (e.g. SSSI or RIGS), although the designation is typically determined by the surface geology rather than the deeper stratigraphy. Such effects would be site specific and therefore the potential effect is uncertain at this stage. However, taking account of scale there is the potential for a facility in a lower strength sedimentary rock type to have a greater impact upon sites of geological importance when compared to the higher strength rock and evaporite rock types due to the increased size in underground facility footprint.</p> <p>In the case of the higher strength rock and evaporite rock types, there would also be the potential for construction of the facility within these host rocks to result in the loss or sterilisation of a mineral resource, or reserve, with the evaporite rock type potentially having a greater effect of the two, due to the larger size of the underground facility footprint when compared to higher strength rock. However, for both host rock types the use of a proportion of the excavated rock for backfilling would negate the need to import any crushed rock for this purpose, which could otherwise affect mineral resources supply elsewhere. The potential also exists for the beneficial use of the remainder of excavated rock to be removed off-site which is particularly the case for evaporite rock type halite, which is used widely in the UK as rock salt for winter de-icing of roads, for chlorine production, for food seasoning and for medicinal purposes. Although the underground facility within lower strength sedimentary rock would have the greatest footprint, construction of a GDF within this host rock type would be unlikely to have a direct effect on minerals resources or reserves, as lower strength argillaceous sedimentary rocks have low commercial value.</p> <p>Excavations into the host rocks could affect the physical or chemical stability or on the background level of seismicity of the surrounding geology. However, although there would be the potential for effects, it is not anticipated that excavation activities would have any significant adverse effects as a stable geological environment is essential for a GDF.</p>	?
5. Water	<p>Water would be required throughout the construction phase for use in construction activities (e.g. for cement mixing, drilling fluid, cleaning machinery, dust suppression, pressure testing and cooling equipment). During construction, water would also be required for potable purposes such as drinking water and canteen use, as well as toilet and washing facilities, and laundering protective clothing. Depending on local water resource availability and demand, there would be the potential for water use to affect water availability, or for environmental flow targets to be affected.</p> <p>Construction activities would generate several sources of water requiring discharge, including surface run-off, groundwater from dewatering, any effluent arising from water use on site and foul water. These could have an effect on water quality and/or receiving water flows. Surface run-off could contain contaminants released through spillage of materials used during construction such as chemicals and fuels. Drilling and excavations may also introduce contaminants to groundwater sources.</p> <p><i>(continued)</i></p>	-



Sustainability Theme	Summary of the Key Issues	Score
<p>5. Water</p>	<p>The removal of potentially significant quantities of groundwater (dewatering) could be required temporarily during the construction of the shafts and drift through near surface geological deposits. The greatest potential for groundwater ingress within excavations would be during construction of the access routes to the underground facility. Once construction reaches the host rock, inflows would be reduced. In the long-term some small inflows would be anticipated, both into the underground accesses (drift and/or shafts), and the underground facility itself.</p> <p>Surface construction activities, particularly site clearance and levelling, and the introduction of hardstanding areas and surface bunds, may increase flood risk by altering surface drainage patterns.</p> <p>There would probably not be any significant difference in potential run-off and flood risk effects between the different waste inventories and host rock types, as the surface site area is assumed to be the same. Notwithstanding this, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site in the case of evaporite rock (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the higher strength rock and lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for evaporite rock, which could reduce any potential surface run-off and flood risk effects.</p> <p>For all host rock types it is assumed that the potential effect of the Derived Inventory Upper Inventory on groundwater could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows and may result in greater levels of dewatering.</p> <p>The different host rock types could affect the scale of any effects on water resources. In the case of lower strength sedimentary rock and evaporite rock (depending upon its type), there would be the potential for excavated rock stored within the surface site area to negatively affect water quality. Lower strength sedimentary rock may contain sufficient sulphide to cause acid generating reactions on exposure to air and water, giving rise to the potential for contamination of surface watercourses. Similarly, the evaporite rock type halite is highly soluble in fresh water and therefore if excavated halite rock were to come in contact with water the potential would exist for the contamination of surface water courses with high chloride waters. The evaporite rock anhydrite, however, is less so, and therefore the pollution risk would be less than that of halite.</p> <p>Permeability varies by rock type, with a greater potential for faults and fracturing within the higher strength rock. The assumed lower strength sedimentary rock has minimal fracturing, and within evaporite rock migration pathways are virtually absent. However, the selection of a suitable host environment would be based on low groundwater flows and at any suitable site the potential for significant groundwater ingress would be low. As noted, the greatest potential for groundwater ingress within excavations would be during construction of the access routes through the near surface geological deposits, which are assumed to be similar for all three host rock types. Notwithstanding this, construction of a GDF within lower strength sedimentary rock could potentially have the greatest effect on groundwater flows as the underground facility footprint of a GDF (7.8km² and 19.5km² for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively) would be greater when compared to the higher strength rock type (4.3km² and 9.8km² respectively) and evaporite rock type (6.5km² and 18.4km² respectively).</p>	<p>-</p>
<p>6. Biodiversity, Flora and Fauna</p>	<p>Surface construction activities with the site and the construction of new road and/or rail infrastructure could result in the loss or fragmentation of habitat. Effects could be direct (e.g. loss to hard engineering or access roads) or indirect (e.g. changes in character due to alterations in drainage patterns and deposition of pollutants). Similarly, any improvements to the local road network required to support construction traffic movements may result in the loss of habitat due to widening or structural upgrading; this is not anticipated to be significant, although there would be the potential for localised loss of features such as species rich hedgerows and specimen trees.</p> <p>Surface construction activities may also lead to disturbance/displacement of wildlife (fauna) as a result of noise (particularly intermittent blasting), human presence and light pollution, with the potential for effects on breeding success and survival. In addition, the accidental release of substances such as diesel, silt laden run-off, and the deposition of pollutants could have an impact.</p> <p><i>(continued)</i></p>	<p>?</p>



Sustainability Theme	Summary of the Key Issues	Score
<p>6. Biodiversity, Flora and Fauna</p>	<p>Depending on its end use, there would also be the potential for the removal of surplus excavated rock off-site to affect biodiversity. For example, direct loss or fragmentation of habitat at the point of loading and unloading for disposal or reuse, or indirect effects due to alterations in drainage patterns or the deposition of pollutants.</p> <p>There would probably not be any significant difference in potential effects on biodiversity between the different waste inventories and host rock types, as the surface site area is assumed to be the same (approximately 1.1km², assuming that the surface site area for evaporite rock includes surface screening bunds).</p> <p>However, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site in the case of evaporite rock (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the higher strength rock and lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for evaporite rock, which could reduce any potential biodiversity effects.</p> <p>At this stage no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the biodiversity value of the site and its surrounds, the sensitivity of any habitats/species present, and the level of habitat disturbance or loss.</p>	<p style="text-align: center;">?</p>
<p>7. Traffic and Transport</p>	<p>There could be a significant increase in traffic movements on the local road network throughout the construction phase associated with construction staff, HGVs, a range of heavy plant construction vehicles, concrete tankers and deliveries, with potential severance, driver delay, pedestrian/cyclist amenity and safety implications.</p> <p>For all host rock types, the greatest numbers of transport movements associated with construction are estimated to arise from the import of construction materials to the site and the removal of surplus excavated rock off-site.</p> <p>There is anticipated to be a greater number of transport movements associated with the removal of excavated rock and the import of construction materials for the ILW/LLW vaults and HLW/SF disposal tunnels for the differing rock types depending on the host rock type considered.</p> <p>For both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory, the evaporite rock type is estimated to generate the largest volume of excavated rock requiring removal off-site when compared to the other host rock type. However, in the case of all of the host rock types, it is proposed that surplus excavated rock would be transported off-site via rail and therefore no significant effects on the road network from the transport of excavated rock are anticipated. For the higher strength rock Derived Inventory Reference Case excluding Pu/U, it is proposed that all of the excavated rock would be retained on site, and therefore no transport of excavated rock from the construction of the underground facilities would be required.</p> <p>For both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory it is estimated that the higher strength rock type could require the greatest number of HGVs when compared to the other host rock types (taking account of the estimated number of HGVs required for the import of construction materials for the construction of the surface-based facilities, drift and shafts, ILW/LLW vaults and HLW/SF disposal tunnels and the common services area). The evaporite rock type is estimated to require the least number of HGVs for the import of construction materials when compared to the other host rock types.</p> <p>HGV estimates for the import of construction materials for the surfaced based facilities, underground accesses (drift and/or shafts), ILW/LLW vaults and HLW/SF disposal tunnels, and the common services area are as follows for each of the host rock types:</p> <ul style="list-style-type: none"> ▪ Approximately 62,300 HGVs and 139,100 HGVs for the higher strength rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively; ▪ Approximately 44,300 HGVs and 89,500 HGVs for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively; and ▪ Approximately 37,300 HGVs and 77,800 HGVs for the evaporite rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively. 	<p style="text-align: center;">--</p>



Sustainability Theme	Summary of the Key Issues	Score
<p>8. Air Quality</p>	<p>As noted in Sustainability Theme 7 (Traffic and Transport), construction of a GDF would result in a significant increase in transport movements on the local road network. Exhaust emissions from traffic could lead to a decrease in local air quality, particularly as a result of increased levels of nitrogen oxides, nitrogen dioxide and particulates. The greatest potential effect could be associated with the import of construction materials to the site.</p> <p>Exhaust emissions from plant and from any use of diesel generators may also contribute to increases in particulate matter and gaseous pollutants (particularly nitrogen dioxide and CO₂). Dust generated during construction activities, particularly earthworks, soil stripping, storage and use of materials on site and excavations could also have an effect on local air quality if unmanaged.</p> <p>For all host rock types, the potential effect of the Upper Inventory could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in the volume of construction materials required and construction waste generated, and an increase in the volume of surplus excavated rock to be removed off-site.</p> <p>As noted in Sustainability Theme 7 (Traffic and Transport), a greater number of HGVs could be required for the import of construction materials for the higher strength rock type (both the Derived Inventory Reference Case excluding Pu/U and Upper Inventory) when compared to the other host rock types (taking account of the estimated transport movements for the import of materials for the construction of the surface-based facilities, access tunnels (drift and/or shafts) and common services area, and for the ILW/LLW vaults and HLW/SF disposal tunnels). Therefore, the transport related air quality effect of the higher strength rock type associated with the import of these construction materials could be greater.</p>	<p>-</p>
<p>9. Climate Change</p>	<p>During the construction phase, there could be significant emissions of CO₂ (due to the direct or indirect combustion of fossil fuel) from construction traffic and plant, any use of diesel generators, and the embodied energy within construction materials used which would contribute to climate change.</p> <p>The construction support facilities or underground facility would not be particularly vulnerable to the effects of climate change other than potential flooding from increased frequency and magnitude of storms if the site was located within an area at risk of flooding or surface water run-off was not managed appropriately. Given that the majority of the construction activities would be underground, changes in weather patterns as climate changes (e.g. very cold winters and hotter drier summers) would be unlikely to significantly affect the construction programme.</p> <p>Should the site be located on the coast, coastal erosion, sea level rise and storm surges could potentially have a negative effect on surface facilities and infrastructure. However, it is assumed given the nature of a GDF that the site would be adequately protected and resilient to coastal change.</p> <p>For all host rock types, the potential effect of the Upper Inventory in relation to transport related carbon emissions, and the carbon embodied in construction material, would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in the volume of construction materials required and construction waste generated, and increase in the volume of surplus excavated rock to be removed off-site.</p> <p>CO₂ emissions associated with the transport of materials for the construction of a GDF (taking account of the transport of construction materials for the construction of the surface-based facilities, underground accesses (drift and/or shafts), common services area and ILW/LLW vaults and HLW/SF disposal tunnels, and the transport of surplus excavated rock off-site) are estimated to be greatest for the higher strength rock type for both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory. CO₂ emissions estimates associated with the transport of construction materials for each of the host rock types are as follows:</p> <ul style="list-style-type: none"> ▪ Approximately 27,800 tonnes of CO₂ and 61,700 tonnes of CO₂ for the higher strength rock Derived Inventory Reference Case excluding Pu/U and Upper Inventory respectively; ▪ Approximately 18,500 tonnes of CO₂ and 38,900 tonnes of CO₂ for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Upper Inventory respectively; and ▪ Approximately 15,800 tonnes of CO₂ and 33,600 tonnes of CO₂ for the evaporite rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively. <p><i>(continued)</i></p>	<p>--</p>



Sustainability Theme	Summary of the Key Issues	Score
9. Climate Change	<p>With respect to embodied carbon, total embodied carbon associated with the construction of the buildings, underground accesses (drift and/or shafts), commons services area, ILW/LLW vaults and HLW/SF disposal tunnels is anticipated to be greater for the higher strength rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory when compared to the other host rock types. Total embodied carbon estimates for each of the host rock types are as follows:</p> <ul style="list-style-type: none"> ▪ Approximately 432,500 tonnes of CO₂ and 1,097,500 tonnes of CO₂ for the higher strength rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively; ▪ Approximately 302,800 tonnes of CO₂ and 774,100 tonnes of CO₂ for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively; and ▪ Approximately 260,800 tonnes of CO₂ and 798,200 tonnes of CO₂ for the evaporite rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively. 	--
10. Noise and Vibration	<p>Construction activities associated with a GDF would probably result in perceptible increases in noise. Significant sources of on-site noise would include excavation works, piling works, earth moving equipment, construction plant, diesel generators, rail traffic and road traffic (HGVs, concrete trucks, forklift trucks, delivery vehicles, vans and personnel vehicles). The construction of the underground facilities, and the movement of excavated rock in particular would be a perceptible source of noise, both continuous background noise and intermittent noise. The surface effects of noise and vibration from excavations would be greater during the initial stages of excavation, reducing as the depth of the excavation increases.</p> <p>Noise disturbance may also arise from sustained, high levels of construction traffic (transport of construction materials and construction wastes, excavated rock and personnel to and from the site) (refer to Sustainability Theme 7, Traffic and Transport).</p> <p>Activities such as piling works, excavation works and HGV movements may also cause vibration effects, although such effects would be difficult to quantify until such time as the ground conditions at the site are known.</p> <p>Depending on the proximity of sensitive receptors to the site, there is the potential for noise and vibration associated with construction activities to have an effect on sensitive receptors (occupants of residential buildings, community and recreational facilities and noise sensitive businesses and enterprises). Whilst activities on site would generate noise and vibration, any effects from on-site noise would probably not be significant due to the need to adhere to the requirements of legislation. However, HGV movements along the local road network may cause a local noise nuisance.</p> <p>There would probably not be any significant difference in noise and vibration effects between the different waste inventories and host rock types, due to the need to adhere to the requirements of legislation.</p> <p>Different construction methods are proposed for the different host rock types, with variable noise and vibration effects. However, the use of different techniques would probably not result in any significant differences, as specified noise limits for the works would need to be adhered to.</p> <p>At this stage, no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the site and works to sensitive receptors and the level and extent of noise and vibration generated.</p>	?
11. Land Use	<p>For all of the host rock types, surface land take is assumed to be approximately 1.1km², assuming that the surface site area for the evaporite rock type includes surface screening bunds. In addition, land take outside of the surface site area may also be required for improvements to, or for the development of new rail and/or road transport infrastructure.</p> <p>There is potential for the construction of a GDF to have an effect on existing land uses, particularly where land take results in the loss or severance of agricultural land or community/recreational land. The significance, particularly the loss of agricultural or community/recreational land would depend on the quality of the land and the characteristics of the area surrounding the site (i.e. the extent of land of equal value in the surrounding area).</p> <p><i>(continued)</i></p>	-



Sustainability Theme	Summary of the Key Issues	Score
11. Land Use	<p>There would probably not be any significant difference in potential land use effects between the different waste inventories and host rock types, as the surface site area is assumed to be the same (approximately 1.1km² for each of the host rock types, assuming that the surface site area for evaporite rock includes surface screening bunds).</p> <p>Notwithstanding this, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site in the case of evaporite rock (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock type (estimated to be 3,589,000m³ in bunds on the site for the higher strength rock and lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that land take could be less for the evaporite rock type.</p>	<p style="text-align: center;">-</p>
12. Socio-economics	<p>Construction activities would generate a number of employment opportunities, a proportion of which may be suitable for the local workforce, and would support local services (e.g. garages, shops, restaurants and accommodation). It is estimated that, on average 886 people per year could be employed during the construction phase, of which 806 people would be directly involved in construction. Taking account of these aspects, and scale and duration of the construction of a GDF, the effects on local employment would be significant and beneficial especially as initial costs, for example training, would be a small proportion of the overall operational expenditure.</p> <p>There is unlikely to be any significant difference in employment opportunity between the different host rock types. There may be variances in the number of staff required for excavated works depending on the excavation method utilised for the different rock types. However, these would be specialist jobs and therefore would probably not have any significant effect on potential local employment opportunities.</p> <p>The agreement and implementation of a community benefits package that would balance the perceived detriment of hosting a GDF with the needs of local communities and their future generations would contribute positively towards socio-economic development.</p>	<p style="text-align: center;">++</p>
	<p>There would be the potential for surplus excavated higher strength rock and evaporite rock released into the market to affect wholesale supply prices; particularly the markets that use evaporites (e.g. road grit and cement production). There would also be the potential for the requirement of significant volumes of construction materials to affect the markets; however the potential effects cannot be ascertained at this stage. Due to its low commercial value, any potential effects associated with the release of surplus excavated lower strength sedimentary rock to the market could be less when compared to the higher strength rock and evaporite rock types. Although this is dependent on the level of demand and availability of supply at the time of arising.</p> <p>There would be the potential for construction activities to have a negative effect on the quality of life of local populations (e.g. associated with the increase in traffic on the road network, noise, vibration and air quality effects from construction works and traffic).</p> <p>There would also be the potential for a GDF to have a negative effect on the desirability of the surrounding area as a place to live, work and invest. Knock-on effects from a GDF could include a decrease in land value and house prices in the local area due to the presence of the facility, which may be viewed as unfavourable. Construction activities could potentially have a negative effect on the viability of businesses in close proximity (e.g. effects on productivity due to disturbance to staff from noisy activities).</p> <p>At this stage, no site has been selected and subsequently the potential for effects on quality of life, business productivity and desirability is uncertain. The potential for effects would depend on the proximity of the site and construction works to sensitive receptors and the level and extent of any disturbance.</p> <p>For all of the host rock types, construction activities for the Derived Inventory Upper Inventory would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility. The potential effect of the Derived Inventory Upper Inventory could therefore be greater than that of the Derived Inventory Reference Case excluding Pu/U.</p>	<p style="text-align: center;">?</p>



Sustainability Theme	Summary of the Key Issues	Score
13. Health and Well-Being	<p>Construction activities may have a negative effect on the health and well-being of local populations (e.g. disturbance from noise and vibrations, and air quality effects from works and traffic).</p> <p>Chronic inhalation of silicate rich rock over a prolonged time period (5 to 10 years) can cause silicosis. There is the potential for silicate to be present within all of the rock types; however the silica content of higher strength rock could potentially be greater than evaporite rock or lower strength sedimentary rock. However, due to the need to adhere to health and safety legislation, there would probably not be any significant difference in potential effects between the different host rock types.</p> <p>The construction of a GDF may be subject to protest action from opposition groups and local communities, which could potentially increase people's fear of crime due to an influx of a large number of people into a local area. However, the use of a transparent, partnership and voluntarism approach to site selection should help to minimise the risk of such action.</p> <p>There may be some beneficial effects on health and well-being through the application of a community benefits package.</p> <p>At this stage no site has been selected and subsequently the potential for effects on health and well-being is uncertain. This depends on the proximity of the site and construction activities to sensitive receptors and the extent of any disturbance. At this stage it is uncertain to what extent there would be active opposition to facility construction.</p>	<p style="text-align: center;">?</p>
14. Safety	<p>Construction activities would present a number of risks to health and safety. Potential hazards include: collision and impact hazards (e.g. involving plant, vehicles and personnel); explosion and detonation (e.g. associated with the use of explosives); exposure to substances hazardous to health (e.g. contact with cement and dusts); entrapment, asphyxiation, and loss of ventilation (e.g. associated with underground works); electrical hazards (e.g. electrical shock from live cables); and other occupational hazards such as working at height and manual handling.</p> <p>Construction activities would probably not present a significant risk to the public (i.e. local communities) provided access to the site was restricted and the relevant health and safety procedures were in place. However, there would be the potential for an increased risk of road traffic accidents associated with any increase in traffic movements arising from the works.</p> <p>Although there are many potential risks associated with construction of a GDF, it is assumed that any risks would have been identified and managed through compliance with health and safety legislation and risk management procedures. The staff working on site would be professionals and would be unlikely to experience any greater risk to safety than at other work locations. Members of the public would not generally be allowed on site. As such, the potential effects would not be significant.</p> <p>For all of the host rock types, it is assumed that construction activities for the Derived Inventory Reference Case excluding Pu/U would be similar in scale to the Derived Inventory Upper Inventory, as health and safety regulations govern the level of construction activity on site and therefore the scale of the works are not expected to increase, instead the construction period would be longer. Therefore there would probably not be a significant difference in potential safety effects between the different waste inventories. However, the length of time involved may increase the statistical chance of accidents occurring.</p> <p>Similarly, due to the need to adhere to the requirements of legislation there would probably not be any significant differences in potential effects between the different host rock types.</p>	<p style="text-align: center;">-</p>
15. Waste	<p>The construction of a GDF would generate large amounts of construction wastes, particularly aggregates of varying size and composition, soil and spoil. For all of the host rock types, the most significant waste stream would be excavated rock from the construction of the underground facilities (refer to Sustainability Theme 4, Geology and Soils). Secondary wastes would include concrete, gypsum and other rendering materials, water, dusts, woods and metals, plastics, packaging and waste oils and drilling fluids. Tertiary wastes would include broken bricks/blocks, nails/bolts, worn tools, canisters, drums (e.g. fuel, diesel, chemicals) and food waste and food packaging from on-site food consumption.</p> <p>It is also expected that there would be some increase in general office waste from the construction support facilities such as paper, organic canteen waste, packaging and possibly some electrical waste from the replacement and upgrades of computers/printers or other electrical products. The average waste figures for UK Government indicate that around 0.45 tonnes of waste is generated per employee per year.</p> <p><i>(continued)</i></p>	<p style="text-align: center;">--</p>



Sustainability Theme	Summary of the Key Issues	Score
<p>15. Waste</p>	<p>Depending on their type, wastes may be sent to landfill, recycled or re-used, for example, as landscaping or as aggregates for construction projects. Some of the waste (some drilling fluid, small amounts of laboratory waste) may be treated as hazardous waste and would need to be handled in compliance with relevant waste regulations.</p> <p>For all host rock types, the potential effect of the Derived Inventory Upper Inventory in relation to waste would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of a GDF, with an associated increase in the volume of construction materials required and construction waste generated, and the increase in the volume of excavated rock to be removed off-site.</p> <p>The types of wastes generated would be similar for the different host rock types. However, the quantities of waste arisings would vary.</p> <p>Construction of a GDF within an evaporite host rock would probably generate the greatest quantities of surplus excavated rock to be removed off-site. Surplus excavated rock arisings are estimated to be as follows for each of the host rock types:</p> <ul style="list-style-type: none"> ▪ 6,640,921m³ for the higher strength rock Derived Inventory Upper Inventory; ▪ 1,231,000m³ and 8,186,000m³ for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory; and ▪ 3,100,879m³ and 8,549,879m³ for the evaporite rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory. <p>There would be no surplus excavated rock for the higher strength rock Derived Inventory Reference Case excluding Pu/U, as all of the excavated rock would be utilised on site for surface bunds and backfilling.</p> <p>Notwithstanding this, in the case of the higher strength rock and evaporite rock types, the potential would exist for the beneficial use of the waste excavated rock to be removed off-site, which would significantly reduce waste excavated rock arising that would require disposal. Evaporite rock in particular could be of commercial value. In the case of the lower strength sedimentary rock, opportunities for the beneficial re-use of the excavated rock could be limited by its low commercial value. Construction of a GDF within lower strength sedimentary rock could therefore generate greater volumes of waste excavated rock due to the potential fewer opportunities for re-use.</p> <p>For all of the host rock types, if none of the surplus excavated rock could be re-used off-site for another purpose this would result in a significant waste stream.</p>	<p>--</p>
<p>16. Resource Use, Utilities and Services</p>	<p>Significant quantities of construction materials would be required for the construction of a GDF. These include concrete, stainless steel/rock bolts and, in the case of the higher strength rock and lower strength sedimentary rock types, explosives for blasting.</p> <p>Key utilities and services that would be required include electricity, water supplies, communications systems, and ventilation systems for construction works underground. This could place additional demand on existing utilities and services, and there may be a requirement for new or additional utilities and services provision.</p> <p>Throughout the construction period there would be an increase in energy use associated with the operation of plant machinery and equipment, site buildings and infrastructure (heating, lighting, canteen facilities and electronics), the operation of ventilation systems to ensure a supply of clean air, and lighting to allow safe working and for security purposes. Diesel generators may be used as a back-up power source but it has been assumed that most of the energy demand would be met from the National Grid.</p> <p>Water would be required for use in construction (e.g. for dust suppression, drilling fluid and cleaning machinery) and for domestic purposes such as drinking water and canteen use as well as toilet and washing facilities (refer to Sustainability Theme 5, Water).</p> <p>Sewerage systems for treatment of wastewater may also be required, depending on whether there is opportunity to connect to the existing network.</p> <p>For all host rock types, the potential effect of the Derived Inventory Upper Inventory would potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in utilities, services and resource use (particularly construction materials).</p> <p><i>(continued)</i></p>	<p>--</p>



Sustainability Theme	Summary of the Key Issues	Score
16. Resource Use, Utilities and Services	<p>Although the types of resources, utilities and services would be similar for the different host rock types, the extent of resource use would vary between the different host rock types. The higher strength rock type is estimated to require the greatest quantities of concrete, with the evaporite rock type requiring the least. Notwithstanding this, it is noted that generally the structural stability and mechanical strength of higher strength rock would be greater, requiring less stainless steel/rock bolts and thus reducing resource requirements for strengthening. In comparison, in the case of the evaporite rock and lower strength sedimentary rock types a greater level of reinforcement would be required to maintain excavations. The greatest level of reinforcement would be required for the evaporite rock due to its creep properties, resulting in the usage of greater quantities of stainless steel/rock bolts.</p> <p>Energy use to power plant could be greater where tunnel boring machines, road headers and continuous miners are utilised, as these machines use more electric power than drill and blast methods. There would also be increased requirements for mobilisation and infrastructure for tunnel boring machines, road headers and continuous miners. Notwithstanding this, construction of a GDF within higher strength rock may require a greater quantity of plant and machinery which would have to be more hard wearing.</p>	- -



4.4 Operation

Table 4.3 presents the summary of the effects of the operation phase.

Table 4.3 Summary of the effects of the operation phase

Sustainability theme	Summary of the key issues	Score
1. Policies and Planning	<p>A GDF would fulfil a number of policy and legislative commitments at international and national level; according with the principles of the IAEA Action Plan, the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, and meeting UK Government requirements for the long-term management of radioactive wastes in accordance with the MRWS programme, irrespective of the rock type it is implemented in.</p> <p>However, the construction of a GDF could be associated with a significant carbon footprint, which if not matched by corresponding reductions elsewhere in the UK economy could detract from the UK meeting its obligations under the Climate Change Act 2008 (refer to Sustainability Theme 9).</p> <p>There would probably not be any significant differences in effects between the different host rock types and waste inventories, as all of the host rock types would meet policy requirements.</p>	+
2. Landscape and Visual	<p>As identified in the construction phase assessment surface development could have a negative landscape and visual effect (i.e. changes in landscape character and alterations to, or loss of existing views). Once a GDF is operational, the surface facilities and infrastructure, access tunnels and the first ILW/LLW vaults would have been constructed, reducing construction works on site and any negative landscape and visual effects associated with these works (e.g. the loss of landscape elements or features in the footprint of development, alterations to the landscape character and the introduction of new visual elements into existing views or the loss of key views).</p> <p>However, the surface facilities and infrastructure would remain on site for the duration of the operational phase, and therefore any negative landscape or visual effect associated with the physical presence of these would remain. In addition, surface activities associated with the construction of the ILW/LLW vaults and HLW/SF disposal tunnels (i.e. the storage and movement of excavated rock), which is anticipated to take place concurrently with disposal throughout the operational phase, could continue to have a negative visual effect. Should surface operational activities extend outside of the surface site area there may be the potential for additional effects.</p> <p>Surface operational activities, in particular movement of material and the delivery and emplacement of radioactive waste could have a negative visual effect. However, it is assumed that the majority of these operations would be contained within the surface buildings and the underground facility, and would therefore have no visual effect in addition to that already considered as part of the construction phase.</p> <p>Lighting for operational, safety and security purposes would be required throughout the operational period. The effects of lighting would be similar to that of the construction phase.</p> <p>Notwithstanding the above, by the operational phase it is assumed that the initial surface bunds would have been constructed and that any visual screening and enhancements implemented during construction would have become more established. These measures could help to reduce visibility into the site and thus help to reduce any landscape and visual effect.</p> <p>No further negative landscape and visual effects are anticipated with respect to the development of, or improvements to, the rail or local road network during the operational phase, as any new infrastructure or improvements to existing infrastructure are assumed to take place during the construction phase. Similarly, no significant effects are anticipated from the transport of radioactive waste by sea (the Sea/Road/Rail scenario), assuming that existing ports are utilised. However, should new port infrastructure be required, the landscape and visual effect of this would need to be assessed.</p> <p><i>(continued)</i></p>	-



Sustainability theme	Summary of the key issues	Score
2. Landscape and Visual	<p>As noted in the construction phase assessment, there would probably not be any significant difference in potential landscape and visual effects between the different waste inventories and host rock types, as the surface site area is assumed to be the same (approximately 1.1km² for each of the host rock types, assuming that the surface site area for the evaporite rock type includes surface screening bunds). Notwithstanding this, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types, there is the possibility that surface disturbance could be less for the evaporite rock type.</p>	-
3. Cultural Heritage	<p>No significant effects on above ground cultural heritage and archaeological sites and features within the site, or on traditional activities, would be anticipated as a result of operational activities, as no further surface disturbance or development in addition to that during the construction phase would be anticipated. However, should surface operational activities extend outside of the development footprint for the construction phase there may be the potential for negative effects.</p> <p>The construction phase assessment identified that surface development could have a negative effect on the setting and amenity of above ground historic or archaeological features and landscapes. Once completed, the surface facilities and infrastructure would remain on site for the duration of the operational phase, and therefore any effects associated with the physical presence of surface development would remain throughout operation. However, it is expected that any visual screening and enhancements implemented during construction would have become more established, which could help to reduce visibility into the site and thus help to reduce any negative effects on the setting and amenity of any nearby cultural heritage resources (refer to Sustainability Theme 2, Landscape and Visual).</p> <p>Surface operational activities, in particular movement of material and the delivery and emplacement of radioactive waste, could have a negative effect on the setting and amenity of above ground historic or archaeological features and landscapes. Although, it is assumed that the majority of these operations would be contained within the surface buildings and the underground facility. As noted above, any visual screening and enhancements could also help to reduce visibility into the site.</p> <p>No significant effects on subsurface and buried archaeological remains are anticipated as a result of operational activities, as although vaults and disposal tunnels would be constructed throughout the operational period as required, these excavations would be within the host rock at depths of at least 500m, where there would be very limited potential for archaeological remains.</p> <p>Pollution from engine exhausts and vibration associated with any increase in rail traffic or road traffic (particularly HGVs in the case of road traffic) (refer to Sustainability Theme 7, Traffic and Transport) could have a negative effect on historic or archaeological features (e.g. listed buildings) by accelerating corrosion/weathering.</p> <p>No significant effects are anticipated from the transport of radioactive waste by sea (the Sea/Road/Rail scenario), assuming that existing ports are utilised. However, should new port infrastructure be required for the transport of radioactive waste by sea, the potential effect of this would need to be assessed.</p> <p>As noted in the construction phase assessment, there would probably not be any significant difference in potential effects on visible above ground cultural heritage or archaeological features between the different waste inventories and host rock types, as the surface site area is assumed to be the same. However, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types, there is the possibility that surface disturbance could be less.</p> <p>There would probably not be any significant difference in potential effects on subsurface or buried archaeological remains between the different host rock types, as excavation activities at a depth greater than 2m are unlikely to have an impact.</p> <p>At this stage no site has been selected and subsequently the predicted effects are uncertain. The potential for effects would depend on the proximity of activities to any cultural heritage and archaeological sites, features and landscapes, the current condition and sensitivity of the site/feature/landscape affected, and the level of disturbance or loss.</p>	?



Sustainability theme	Summary of the key issues	Score
4. Geology and Soils	<p>No significant effects on soil reserves would occur as a result of operational activities as no further site clearance works or disturbance to soils are anticipated. However, should surface operational activities extend outside of the surface site area for the construction phase there may be the potential for effects.</p> <p>There would be the potential for some of the operational activities such as the transport of construction materials, radioactive wastes and backfill material on site to introduce some low level contamination to the local environment (including, for example, silty water, drill fluid and oil spillages). This risk could be sufficiently mitigated following best practice guidance, and is considered to be negligible.</p> <p>Once a GDF becomes operational, the surface facilities and infrastructure, surface bunds, underground accesses (drift and/or shafts) and the first ILW/LLW vaults would have been constructed, reducing construction works on site. Therefore no further effects associated with these works would be anticipated. However, construction of the ILW/LLW vaults and HLW/SF disposal tunnels would take place concurrently with disposal throughout the operational phase.</p>	-
	<p>Once a GDF becomes operational no significant effects on sites of recognised importance for their geological value (e.g. SSSI or RIGS) are anticipated, as no further surface disturbance or development would be anticipated. However, should surface operational activities extend outside of the development footprint for the construction phase there may be the potential for negative effects on such sites.</p> <p>As noted in the construction phase assessment, in the case of the higher strength rock there would be the potential for underground excavations into these host rocks to result in the loss or sterilisation of a mineral resource/reserve, with the evaporite rock potentially having the greatest effect due to the increased size of the underground facility footprint. However, for both host rock types the use of a proportion of the excavated rock for backfilling would negate the need to import any crushed rock for backfilling, which could otherwise affect mineral resources supply elsewhere. The potential also exists for the beneficial use of the remainder of excavated rock to be removed off-site, in particular the evaporite rock type halite, which is used widely in the UK as rock salt for winter de-icing of roads, for chlorine production, for food seasoning and for medicinal purposes.</p> <p>Although the underground facility for the lower strength sedimentary rock type would have the greatest underground footprint, underground excavations into lower strength sedimentary rock would be unlikely to have a direct effect on minerals resources or reserves, as lower strength argillaceous sedimentary rocks have low commercial value. However, during the operational phase in the case of the higher strength rock and the lower strength sedimentary rock, significant quantities of bentonite (refer to Sustainability Theme 16, Resource Use, Utilities and Services) would need to be imported for the backfilling of the HLW/SF disposal tunnels, which could have an effect on minerals resources and reserves elsewhere. The potential effect could be greater for the higher strength rock type than that of lower strength sedimentary rock, as a greater quantity of bentonite would be required. The evaporite rock type would potentially have the least effect on minerals resources or reserves associated with the import of backfill material, as only MgO would need to be imported for this purpose.</p> <p>The physical presence of radioactive waste packages within the underground facility would be unlikely to have any effect on the physical stability or the background level of seismicity in the surrounding geology. There would be some potential risk to waste container integrity from structural failures (e.g. rock falls). However, sufficient rock support of a high standard would be provided to ensure long-term structural stability.</p> <p>There would be the potential for heat from the high level radioactive wastes to damage engineered barriers, backfill and host geology. However, the waste disposal areas would be designed to ensure, as far as possible, that waste temperatures would not exceed specifications. The waste packages would also be designed to ensure they retained their integrity for many hundreds of years.</p>	?



Sustainability theme	Summary of the key issues	Score
<p>5. Water</p>	<p>Similar to the construction phase, water would be required throughout the operational phase for use in ILW/LLW vault and HLW/SF disposal tunnel construction activities (including, for example, cement mixing, drilling fluid, cleaning machinery and cooling equipment); for routine processes such as wash-down and decontamination; and for potable purposes such as drinking water and canteen use, as well as toilet and washing facilities and laundering protective clothing. Depending on local water resource availability and demand at the site, there would be the potential for water use to affect water availability, or for environmental flow targets to be affected.</p> <p>Operational activities would generate several sources of water requiring discharge, including surface run-off; foul water; effluent from groundwater inflow, de-humidification operations and decontamination processes. These could have an effect on water quality and/or flows of receiving waters. Surface run-off could contain contaminants released through spillage of materials such as chemicals and fuels.</p> <p>Excavation of the ILW/LLW vaults and HLW/SF disposal tunnels may also introduce contaminants to groundwater sources (e.g. drilling or boring fluid).</p> <p>The presence of the underground facility within the host rock, and any grouting/lining in the drift, shafts and tunnels as required, would reduce the transmissive capacity of water bearing formations (aquifers) on a localised scale, acting as a barrier to normal flow patterns. Throughout the operational phase, groundwater flows would require monitoring and control by engineered systems, which may include the diversion of flows to specific collection or drainage points, and storage, monitoring and treatment of the effluent.</p> <p>No further effects relating to flood risk in addition to those identified in the construction phase assessment are anticipated, as no further site preparation, levelling and surface construction is anticipated.</p> <p>No significant effects on water quality would be anticipated from the transport of radioactive waste by sea (the Sea/Road/Rail scenario), assuming that existing ports and purpose built ships would be utilised, and the necessary precautions would be taken. However, it should be noted that there could be the potential for a serious pollution incident where a tanker gets into difficulty (i.e. runs aground or capsizes), resulting in the spillage of oil or radioactive waste. Should new port infrastructure be required for the transport of radioactive waste by sea, the potential for effects on water quality would need to be assessed.</p> <p>For all three host rock types, the potential effect of the Derived Inventory Upper Inventory on groundwater flows could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility footprint.</p> <p>The different host rock types could affect the scale of any effects on water resources. In the case of lower strength sedimentary rock and evaporite rock (depending upon its type), excavated rock stored within the surface site area could negatively affect water quality. Lower strength sedimentary rock may contain sufficient sulphide to cause acid generating reactions on exposure to air and water. Similarly, the evaporite rock type halite is highly soluble in fresh water and therefore if excavated halite rock were to come in contact with water the potential would exist for the contamination of surface watercourses with high chloride waters. The evaporite rock anhydrite, however, is less soluble, and therefore the pollution risk would be less than that of halite.</p> <p>Permeability varies by rock type, with a greater potential for faults and fracturing within the higher strength rock. The assumed lower strength sedimentary rock would have minimal fracturing, and within evaporite rock such as rock salt migration pathways are virtually absent. However, as the selection of a suitable host environment would be based on low groundwater flows, the potential for significant groundwater ingress would be low. Notwithstanding this, the presence of a GDF within lower strength sedimentary rock could potentially have the greatest effect on groundwater flows as the underground facility footprint of a GDF (7.8km² and 19.5km² for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively) would be greater when compared to the higher strength rock type (4.3km² and 9.8km² respectively) and evaporite rock type (6.5km² and 18.4km² respectively).</p>	-



Sustainability theme	Summary of the key issues	Score
<p>6. Biodiversity, Flora and Fauna</p>	<p>Assuming that all operational activities would take place within the surface site area, there would be no further land take during the operational phase. Therefore no further effects on biodiversity would be anticipated as a result of land take (i.e. direct loss or fragmentation of habitat to hard engineering). However, there would be the potential for continued disturbance/displacement of species as a result of operational activities (e.g. such as noise (particularly intermittent blasting), human presence and light pollution), which could reduce the rates of breeding success and survival. The accidental release of substances such as diesel, silt laden run-off, and the deposition of pollutants associated with transport movements could also negatively affect biodiversity.</p> <p>No significant effects on biodiversity would be anticipated from the transport of radioactive waste by sea (the Sea/Road/Rail scenario), assuming that existing ports and purpose built ships are utilised, and the necessary precautions are taken. However, should new port infrastructure be required for the transport of radioactive waste by sea, the potential for effects on biodiversity would need to be assessed.</p> <p>There would probably not be any significant difference in potential effects on biodiversity between the different waste inventories, as the surface site area is assumed to be the same (approximately 1.1km², assuming that the surface site area for evaporite rock includes surface screening bunds). However, as noted in the construction phase assessment, although the surface site area is assumed to be the same for each of the host rock types, given that a smaller volume of excavated rock would be stored on site for evaporite rock, surface disturbance could be less, which could reduce any potential biodiversity effects.</p> <p>At this stage, no site has been selected and subsequently the predicted effects are uncertain. The potential for effects would depend on the biodiversity value of the site and its surrounds, the sensitivity of any habitats/species present, and the level of habitat disturbance or loss.</p>	<p>?</p>
<p>7. Traffic and Transport</p>	<p>Transport movements associated with a GDF would remain elevated throughout the operational phase, associated with the transport of construction material, excavated rock, radioactive waste, site staff, a range of heavy plant construction vehicles, concrete tankers and deliveries. The greatest number of transport movements generated during the operational phase would be associated with the removal of excavated rock off-site and the transport of radioactive waste and backfill material to the site.</p> <p>Construction of a GDF has been assessed as a discrete phase; however, in reality construction of the ILW/LLW vaults and HLW/SF disposal tunnels would take place concurrently with disposal throughout the operational phase. Therefore during the operational phase, there would also be transport movements associated with the removal of the excavated rock and the import of construction materials for the higher strength rock ILW/LLW vaults and HLW/SF disposal tunnels.</p> <p>For all host rock types, the potential traffic and transport effect of the Derived Inventory Upper Inventory would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in the volume of construction materials required and construction waste generated, an increase in the volume of excavated rock to be transported off-site, an increase in the volume of buffer/backfill material required, and increase in the volume of radioactive waste, resulting in a greater number of transport movements.</p> <p>For both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory, it is estimated that the higher strength rock type could require the greatest number of HGVs for the import of buffer/backfill materials for the ILW/LLW vaults and HLW/SF disposal tunnels, when compared to the lower strength sedimentary rock and evaporite rock types. The evaporite rock type is estimated to require the least number of HGVs for the import of buffer/backfill material when compared to the other host rock types, as only MgO sacks would need to be imported to the site. HGV estimates for the import of buffer/backfill materials for each of the host rock types are as follows:</p> <ul style="list-style-type: none"> ▪ Approximately 75,300 HGVs and 186,400 HGVs for the higher strength rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively; ▪ Approximately 46,100 HGVs and 111,500 HGVs for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively; and ▪ Approximately 6,300 HGVs and 15,600 HGVs for the evaporite rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively. <p>For the higher strength rock and lower strength sedimentary rock types it is noted that bentonite would need to be imported for the backfilling of the HLW/SF disposal tunnels. Bentonite is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport impact.</p> <p><i>(continued)</i></p>	<p>--</p>



Sustainability theme	Summary of the key issues	Score
7. Traffic and Transport	<p>For all host rock types, two transport scenarios have been considered for the transport of radioactive wastes; Road/Rail and Sea/Road/Rail. The potential effect of transporting radioactive waste predominantly by rail ((the Road/Rail scenario, which assumes a 70:30 rail and road split) could be greater than if radioactive waste is transported by sea (the Sea/Road/Rail scenario, which assumes a 80:10:10 sea, road and rail split), as more transport movements by road would be required. There would not be any difference in potential effect associated with the transport of radioactive waste for the different host rock types, as all would be designed to accept the same volumes of radioactive wastes.</p>	<p>-</p>
8. Air Quality	<p>As noted in Sustainability Theme 7 (Traffic and Transport), there would be a significant increase in traffic movements on the local road network throughout the operational phase. Exhaust emissions from traffic could lead to a decrease in local air quality, particularly from nitrogen oxides, nitrogen dioxide and particulates. The greatest potential effect could be associated with the transport of construction materials, buffer/backfill material and radioactive waste to the site.</p> <p>Exhaust emissions from plant and diesel engine emissions from any use of diesel generators used to supply non mains power may also contribute to increases in particulate matter and gaseous pollutants (particularly nitrogen dioxide and CO₂).</p> <p>Once a GDF is operational, activities associated with the construction of the drift, shafts and the first vaults would have been completed and therefore no further air quality effects associated with these works are anticipated. However, construction of the ILW/LLW vaults and HLW/SF disposal tunnels would take place concurrently with disposal throughout the operational phase. Dust generated from vault and disposal tunnel construction and backfill activities, particularly storage and use of materials on site, and excavations, could have an effect on local air quality if unmanaged.</p> <p>The facility would comprise a ventilation system to remove flammable gases, fumes or dust generated by underground activities. Throughout operation there would be on-site emissions of dust and fumes/gases via the venting stacks which could negatively affect local air quality.</p> <p>For all host rock types, the effect of the Derived Inventory Upper Inventory could be potentially greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in the volume of construction materials required and waste generated, surplus excavated rock to be removed off-site, backfill material required, and volume of radioactive waste to be disposed of, resulting in a greater number of transport movements.</p> <p>As noted in Sustainability Theme 7 (Traffic and Transport), taking account of the estimated transport movements for the import of construction materials and buffer/backfill materials to the site, a greater number of HGVs could be required for higher strength rock when compared to the other host rock types. Therefore the transport related air quality effect of the higher strength rock type associated with the import of construction materials and buffer/backfill material could be greater.</p> <p>For the higher strength rock and lower strength sedimentary rock types it is also noted that bentonite would need to be imported for the backfilling of the HLW/SF disposal tunnels. Bentonite is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport related air quality impact.</p> <p>The transport of radioactive waste predominantly by rail (the Road/Rail scenario, which assumes a 70:30 rail and road split) could have a greater impact upon air quality when compared to transporting radioactive waste predominantly by sea (the Sea/Road/Rail scenario, which assumes a 80:10:10 sea, road and rail split), as a greater number of transport movements would be by road. As noted in the climate change assessment (refer to Sustainability Theme 9), CO₂ emissions for the Road/Rail scenario are estimated to be greater than that of the Sea/Road/Rail scenario.</p>	<p>-</p>
9. Climate Change	<p>The emission of significant quantities of CO₂ during operation (due to the direct or indirect combustion of fossil fuel) from traffic and plant, any use of diesel generators to power drilling rigs and associated plant for the construction of the ILW/LLW vaults and HLW/SF disposal tunnels, the embodied energy in construction materials used, and the on-site emissions of dust and fumes/gases via the venting stacks would contribute to climate change.</p> <p>For all host rock types, the effect of the Derived Inventory Upper Inventory would be potentially greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in construction materials required and construction wastes, an increase in the volume of surplus excavated rock to be removed off-site, an increase in the volume of backfill material required, and increase in the volume of radioactive waste to be disposed of.</p> <p><i>(continued)</i></p>	<p>--</p>



Sustainability theme	Summary of the key issues	Score
<p>9. Climate Change</p>	<p>CO₂ emissions would vary between the different host rock types. For both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory, the higher strength rock type would probably generate the greatest amount of carbon emissions associated with the transport of buffer/backfill material for the ILW/LLW vaults and HLW/SF disposal tunnels when compared to the other host rock types.</p> <p>CO₂ emissions estimates for the transport of buffer/backfill material for each of the host rock types are as follows:</p> <ul style="list-style-type: none"> ▪ Approximately 39,000 tonnes of CO₂ and 96,600 tonnes of CO₂ for the higher strength rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively; ▪ Approximately 33,200 tonnes of CO₂ and 84,400 tonnes of CO₂ for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively; and ▪ Approximately 23,100 tonnes of CO₂ and 65,400 tonnes of CO₂ for the evaporite rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively. <p>For higher strength rock and lower strength sedimentary rock it is noted that bentonite would need to be imported for the backfilling of the HLW/SF disposal tunnels. Bentonite is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport related CO₂ emissions.</p> <p>CO₂ emissions associated with the transport of radioactive waste would be the same for each host rock type, as they facilities would be designed to accept the same volumes of radioactive waste.</p> <p>Overall for the construction and operational phase, (taking account of the CO₂ emissions estimates for the transport of surplus excavated rock off-site, for the transport of construction materials for ILW/LLW vault, HLW/SF disposal tunnel, underground accesses (drift and/or shafts) and common service area, and ILW/LLW vault and HLW/SF buffer/backfill material), for the Derived Inventory Reference Case for the evaporite rock type would probably generate the greatest amount of transport related CO₂ emissions, as although fewer construction and buffer/backfill materials would be required when compared to the other host rock types, a significantly greater volume of surplus excavated rock would need to be removed off-site.</p> <p>For the Derived Inventory Upper Inventory the lower strength sedimentary rock type would probably generate the greatest amount of transport related CO₂ emissions, due to the volume of surplus excavated rock to be removed off-site and the volume of construction materials and buffer/backfill materials to be transported to the site.</p> <p>Total CO₂ emissions estimates for each of the host rock types are as follows:</p> <ul style="list-style-type: none"> ▪ Approximately 66,800 tonnes of CO₂ and 412,500 tonnes of CO₂ for the higher strength rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively; ▪ Approximately 98,800 tonnes of CO₂ and 436,700 tonnes of CO₂ for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively; and ▪ Approximately 157,600 tonnes of CO₂ and 426,300 tonnes of CO₂ for the evaporite rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively. 	<p>--</p>
<p>10. Noise and Vibration</p>	<p>There would continue to be noise disturbance during the operational phase (e.g. from excavations, earth moving equipment, construction plant, rail and road traffic (HGVs, concrete trucks, forklift trucks, delivery vehicles, vans and personnel vehicles). The construction of the underground facilities, and the movement of excavated rock in particular would be a perceptible source of noise, both continuous background noise and intermittent noise.</p> <p>Noise disturbance may also arise from sustained high levels of traffic (transport of construction materials and construction wastes, excavated rock, buffer/backfill material and radioactive wastes) (refer to Sustainability Theme 7, Traffic and Transport).</p> <p>Activities, such as excavations and HGV movements, may also have vibration effects, although such effects would be difficult to quantify until such time as the ground conditions at the site are known.</p> <p><i>(continued)</i></p>	<p>?</p>



Sustainability theme	Summary of the key issues	Score
10. Noise and Vibration	<p>Depending on proximity, there is the potential for noise and vibration to have an effect on sensitive receptors (occupants of residential buildings, community and recreational facilities and noise sensitive businesses and enterprises). Whilst activities on site would generate noise and vibration, any effects from on site noise would probably not be significant due to the need to adhere to the requirements of legislation. However, there would be potential for HGV movements along the local road network to cause a noise nuisance.</p> <p>There would probably not be any significant difference in noise and vibration effects between the different waste inventories and host rock types, due to the need to adhere to the requirements of legislation.</p> <p>Different construction methods are proposed for the different host rock types, with variable noise and vibration effects. However, the use of different techniques would be unlikely to result in any significant differences, as specified noise limits for the works would need to be adhered to.</p> <p>At this stage no site has been selected and subsequently the predicted effect is uncertain. The potential for effects would depend on the proximity of the site and works to sensitive receptors and the level and extent of noise and vibration generated.</p>	?
11. Land Use	<p>The surface site area of a GDF would remain fenced off and inaccessible throughout the operational phase, and therefore any effects on land use would remain. The significance of the land take, particularly loss of agricultural or community/recreational land would depend on the quality of the land and the characteristics of the area surrounding the site (i.e. the extent of land of equal value in the surrounding area).</p> <p>No significant effects would be anticipated from the transport of radioactive waste by sea (the Sea/Road/Rail scenario), assuming that existing ports are utilised. However, should new port infrastructure be required for the transport of radioactive waste by sea, the land use effect of this would need to be assessed.</p> <p>As noted in the construction phase assessment, there would probably not be any significant difference in potential land use effects between the different waste inventories and host rock types, as the surface site area is assumed to be the same (approximately 1.1km² for each of the host rock types, assuming that the surface site area for evaporite rock includes surface screening bunds). However, although the surface site area is assumed to be the same for each of the host rock types, given that a smaller volume of excavated rock would be stored on site for evaporite rock when compared to the other host rock types, there is the possibility that land take could be less for the evaporite rock type.</p>	-
12. Socio-economics	<p>Operational activities would generate a number of employment opportunities, a proportion of which may be suitable for the local workforce, and would support local services (e.g. garages, shops, restaurants and accommodation). The NDA estimate that, on average 623 people per year could be employed during the operational phase (including manpower for further construction), for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory. Taking account of the scale and duration of the operational phase, the effects on local employment would be beneficial. However, there would be a reduction in employment from the construction phase.</p> <p>There would probably not be any significant difference in employment opportunity between the different host rock types. There may be variances in the number of staff required for excavation works depending on the excavation method utilised. However, these would be specialist jobs and therefore would be unlikely to have any significant effect on potential local employment opportunities.</p> <p>The agreement and implementation of a community benefits package that would balance the perceived detriment of hosting a GDF with the needs of local communities and their future generations is likely to positively contribute towards socio-economic development.</p>	+
	<p>Similar to construction, throughout operation there would be the potential for a GDF, as a major user and producer of materials, to affect supply chains and local prices. The effect would depend on the availability and demand for resources. There would be the potential for surplus excavated higher strength and evaporite rock released into the market to affect wholesale supply prices, particularly the markets that use evaporite rock (e.g. road grit and cement production). There would also be the potential for the requirement of significant volumes of construction materials to affect the markets; however the potential effects cannot be ascertained at this stage.</p> <p><i>(continued)</i></p>	?



Sustainability theme	Summary of the key issues	Score
12. Socio-economics	<p>Due to its low commercial value, any potential effects associated with the release of surplus excavated lower strength sedimentary rock to the market could be less when compared to the other host rock types. Although this would be, to some extent, dependent on the level of demand and availability of supply at the time of arising.</p> <p>Similar to construction, operational activities could continue to have a negative effect on the quality of life of local populations (e.g. associated with traffic on the road network, noise, vibration and air quality effects from works and traffic).</p> <p>A GDF may also have a continued negative effect on the desirability of the surrounding area as a place to live, work and invest. Knock-on effects from a GDF could include a decrease in land value and house prices in the local area due to the presence of the facility, which may be viewed as unfavourable. Operational activities may also have a negative effect on the viability of businesses in close proximity (e.g. effects on productivity due to disturbance to staff from noisy activities).</p> <p>For all of the host rock types, construction/operation for the Derived Inventory Upper Inventory GDF would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility and therefore the potential effect of the Derived Inventory Upper Inventory could be greater.</p> <p>At this stage no site has been selected and subsequently the potential for effects on quality of life, business productivity and desirability is uncertain. The potential for effects would depend on the proximity of the site to sensitive receptors and the level and extent of any disturbance.</p>	?
13. Health and Well-Being	<p>Similar to construction, operational activities may have a negative effect on the health and well-being of local populations (e.g. disturbance from noise and vibrations, and air quality effects from works and traffic). However, there may also be some beneficial effects on health and well-being from a community benefits package.</p> <p>A GDF may be subject to protest action from opposition groups and local communities, which could potentially increase people's fear of crime due to an influx of a large number of people into a localised area. It is considered that the beginning of waste emplacement at a GDF may attract the greatest degree of protest action from opposition groups, which may decrease in the longer-term. However, the use of a transparent, partnership and voluntarism approach to site selection should help to minimise the risk of such action.</p> <p>It is likely that there would be concerns regarding health and safety associated with the delivery, transfer and emplacement of radioactive waste at a GDF. There would be the potential for the perceived risks associated with a GDF to cause concern, which could affect people's health and well-being (e.g. increased/elevated stress levels). The consideration of radiological effects is outside the scope of this assessment. However, a GDF and associated transport infrastructure would be designed to meet regulatory requirements with regard to the protection of the environment and public from radiological hazards. The level of protection would be consistent with the national standard at the time of disposal.</p> <p>Operational activities for the Derived Inventory Upper Inventory would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility. The potential effects of the Derived Inventory Upper Inventory on health and well-being could therefore be greater than that of the Derived Inventory Reference Case excluding Pu/U.</p> <p>At this stage no site has been selected and subsequently the potential for effects on health and well-being is uncertain. This depends on the proximity of the site and construction activities to sensitive receptors and the extent of any disturbance. At this stage it is uncertain what extent and what magnitude opposition may be.</p>	?
14. Safety	<p>Similar to construction, operational activities would present a number of risks to health and safety. Potential hazards would include: collision and impact hazards (e.g. involving plant, vehicles and personnel); explosion and detonation (e.g. associated with the use of explosives); exposure to substances hazardous to health (e.g. contact with cement and dusts); entrapment, asphyxiation, and loss of ventilation (e.g. associated with underground works); electrical hazards (e.g. electrical shock from live cables); and other occupational hazards such as working at height and manual handling.</p> <p>Operational activities would be unlikely to present a significant risk to the public (i.e. local communities) provided access to the site was restricted and the relevant health and safety procedures were in place.</p> <p><i>(continued)</i></p>	-



Sustainability theme	Summary of the key issues	Score
<p>14. Safety</p>	<p>However, there may be an increased risk of road traffic accidents associated with any increase in traffic movements arising from the operations. A GDF and associated transport infrastructure would be designed to meet regulatory requirements with regard to the protection of the environment and public from radiological hazards. The level of protection would be consistent with the national standard at the time of waste disposal.</p> <p>Although there are many potential risks associated with operational activities, it is assumed that any risks would have been identified and managed through compliance with health and safety legislation and risk management procedures. The staff working on site would be professionals and would be unlikely to experience any greater risk to safety than at other work locations. Members of the public would not normally be allowed on site. As such, the potential effects would probably not be significant.</p> <p>For all of the host rock types, it is assumed that construction activities for the Derived Inventory Reference Case excluding Pu/U would be similar in scale to the Derived Inventory Upper Inventory, as health and safety regulations govern the level of activity on site and therefore the scale of the works are not expected to increase, instead the operational period would be longer. Therefore, there would probably not be a significant difference in potential safety effects between the different waste inventories. However, the length of time involved may increase the statistical chance of accidents occurring.</p> <p>There would probably not be any significant differences in potential effects between the different host rock types, due to the need to adhere to the requirements of legislation.</p>	<p>-</p>
<p>15. Waste</p>	<p>Once a GDF is in operation, construction of the surface facilities and infrastructure, drift, shafts and the first vaults would have been completed, reducing construction works on site and any waste arisings associated with these works. However, the construction of the ILW/LLW vaults and HLW/SF disposal tunnels would be ongoing throughout the operational period, anticipated to take place concurrently with radioactive waste disposal.</p> <p>As noted in the construction phase assessment summary, for all of the host rock types, the most significant waste stream would be excavated rock from the construction of the underground facilities (refer to Sustainability Theme 4, Geology and Soils).</p> <p>Secondary wastes include concrete, gypsum and other rendering materials, buffer and backfill material, water, dusts, woods and metals, plastics, packaging and waste oils and drilling fluids. Tertiary wastes include broken bricks/blocks, nails/bolts, worn tools, canisters, drums (e.g. fuel, diesel, chemicals) and food waste and food packaging from on-site food consumption.</p> <p>It is also expected that there would continue to be general office waste from the support facilities such as paper, organic canteen waste, packaging and possibly some electrical waste from the replacement and upgrades of computers/printers or other electrical products.</p> <p>Depending on their type, wastes may be sent to landfill, recycled or re-used, for example, as landscaping or as aggregates for construction projects. Some of the waste (some drilling fluid, small amounts of laboratory waste) may be treated as hazardous waste and would need to be handled in compliance with relevant waste regulations.</p> <p>For all host rock types, the potential effect of the Derived Inventory Upper Inventory in relation to waste would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of a GDF, with an associated increase in the volume of construction materials required and construction waste generated, and the increase in the volume of excavated rock to be removed off-site.</p> <p>As noted in the construction phase summary, the quantities of waste arisings would probably vary for the different host rock types. Construction of a GDF within the evaporite rock would probably generate greater quantities of surplus excavated rock requiring off-site disposal for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory. Notwithstanding this, in the case of the higher strength rock and evaporite rock types, the potential would exist for the beneficial use of the waste excavated rock to be removed off-site, which would significantly reduce waste excavated rock arising that would require disposal. Evaporite rock in particular is of commercial value. In the case of the lower strength sedimentary rock type, opportunities for the beneficial re-use of the excavated rock could be limited due to its low commercial value. The lower strength sedimentary rock type could therefore generate greater volumes of waste excavated rock due to fewer opportunities for re-use.</p>	<p>--</p>



Sustainability theme	Summary of the key issues	Score
<p>16. Resource Use, Utilities and Services</p>	<p>During the operational phase, the greatest level of resource use would be associated with the construction of the ILW/LLW vaults and HLW/SF disposal tunnels (taking place concurrently with disposal throughout the operational phase) and the subsequent backfilling of the ILW/LLW vaults and HLW/SF disposal tunnels.</p> <p>Key utilities and services that would be required include electricity, water supplies, communications systems, and underground ventilation systems. This could place additional demand on existing utilities and services, and there may be a requirement for new or additional utilities and services provision.</p> <p>Throughout the operational phase there would continue to be energy use associated with the operation of plant machinery and equipment, site buildings and infrastructure (heating, lighting, canteen facilities and electronics), the operation of ventilation systems to ensure a supply of clean air, and lighting to allow safe working and for security purposes.</p> <p>Diesel generators may be used as a back-up power source but it is assumed that most of the energy demand would be met from the National Grid.</p> <p>Water would be required (e.g. for dust suppression, drilling fluid and cleaning machinery) and for domestic purposes such as drinking water and canteen use as well as toilet and washing facilities (refer to Sustainability Theme 5, Water). Sewerage systems for treatment of wastewater may also be required, depending on whether there was an opportunity to connect to the existing network.</p> <p>For all host rock types, the effect of the Derived Inventory Upper Inventory would probably be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in utilities, services and resource use (particularly construction materials).</p> <p>Similar to the construction phase, although the types of resources, utilities and services would be similar for the different host rock types, the extent of resource use would probably vary between the different host rock types. In terms of buffer and backfill resource use, in the case of the higher strength rock and evaporite rock, requirements for crushed rock backfill material for backfilling of the HLW/SF disposal tunnels could be met on site using rock from the excavation of the underground facilities. In the case of the lower strength sedimentary rock type, none of the excavated rock would meet backfill requirements, and as a result all crushed rock backfill material would need to be imported.</p> <p>It is estimated that a greater quantity of bentonite, 714,000m³ and 1,946,000m³ in total, would be required for buffer/backfill for the higher strength rock type (Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively), compared to 257,000m³ and 713,000m³ of bentonite for the lower strength sedimentary rock type (Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively). It is noted that bentonite is not widely available in the UK and therefore may need to be shipped from abroad.</p> <p>However, it is estimated that a greater quantity of NRVB, 1,050,000m³ and 2,540,000m³ in total, would be required for buffer/backfill for the lower strength sedimentary rock (Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively), compared to 1,000,000m³ and 2,300,000m³ of NRVB for the higher strength rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively.</p> <p>No bentonite or NRVB would be required for the evaporite rock type. As only buffer material would be required to be imported for the evaporite rock (due to the nature of the host geology there would not be any requirement for ILW/LLW vault backfill material), resource use for buffering/backfilling is anticipated to be much lower for evaporite rock when compared to the other host rock types.</p>	<p style="text-align: center;">--</p>



4.5 Closure and post-closure

Table 4.4 presents the summary of the effects of the closure and post-closure phase.

Table 4.4 Summary of the effects of the closure and post-closure phase

Sustainability Theme	Summary of the Key Issues	Score
1. Policies and Planning	At this stage, given the substantial time period that would have passed by the time a decision is reached to close a GDF, the potential effect of this phase in relation to policies and planning cannot be determined. The effect of the closure and post-closure phase on policies and planning would depend on the evolution of the future policy and planning framework.	?
2. Landscape and Visual	<p>During closure the remaining underground roadways, facilities and underground accesses would be backfilled. Surface activities associated with backfilling, sealing and closure, and decommissioning of the surface facilities and infrastructure, could have a negative landscape and visual effect. However, any activities would be of a similar, or lesser, scale and nature as that of the proposed operational activities and it is assumed that closure activities would take place within the surface site area. By the closure phase it is also assumed that any visual screening and enhancements around the site would be well established. This could help to reduce visibility into the site and thus help to reduce any negative effects.</p> <p>Following the decommissioning of the surface facilities and infrastructure, it is assumed that the site would be restored to as near its preconstruction condition as practicable. The landscape and visual effect could be positive following restoration where surface structures that affect the visual amenity of local receptors were removed and where restoration works took into account existing landscape character, provided the restoration of the site did not result in the fragmentation or loss of any valued landscape elements or features. Given the substantial time period that would have passed since the construction of a GDF, it may have become an established element of the landscape, perceived as part of the landscape character. Any planting undertaken as part of landscape and biodiversity mitigation would have become well established and could be regarded as a valued feature. It is also possible, although less likely, that surface facilities could also be regarded as valued features. Any loss of valued features could have a negative landscape and visual effect.</p> <p>The only structures that are assumed to remain on site are the surface bunds, therefore any landscape and visual effect associated with the presence of these bunds would remain.</p> <p>For all of the host rock types there would probably not be any significant difference in landscape and visual effects between the different waste inventories, as the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore a similar level of closure and post-closure activity would take place on the surface.</p> <p>Similarly, there would probably not be any significant difference in landscape and visual effects associated with backfilling, sealing and closure, and the decommissioning of the surface facilities and infrastructure between the different host rock types, as a similar level of activity would take place on the surface. However, following decommissioning and site restoration, the scale of any residual effect could differ between the different host rock types. Assuming that a dedicated storage area for excavated rock would be demolished as part of decommissioning, any potential residual landscape and visual effect could be less for the evaporite rock type as only the surface screening bunds would remain on site. These could be of a smaller volume than the surface bunds for the higher strength rock and lower strength sedimentary rock types, which are assumed to comprise up to 3,589,000m³ of excavated rock.</p>	?



Sustainability Theme	Summary of the Key Issues	Score
3. Cultural Heritage	<p>There would be the potential for surface activities associated with backfilling, sealing and closure, and decommissioning of the surface facilities and infrastructure to have a negative effect on the setting and amenity of above ground historic or archaeological features and landscapes (e.g. the movement of seal and backfill material). However, any closure works would be of a similar, or lesser, scale and nature as that of the proposed operational activities. By the closure phase it is also assumed that any visual screening and enhancements implemented during construction would have become well established; potentially reducing visibility into the site and helping to reduce any negative effects.</p> <p>No significant effects on above ground cultural heritage and archaeological sites and features or traditional activities would be anticipated as a result of closure activities, as there would be no further disturbance or development on the surface. Similarly, no significant effects on subsurface and buried archaeological remains would be anticipated as a result of backfilling, sealing and closure activities, as no further excavation works would be undertaken.</p> <p>Following closure, it is assumed that the surface facilities would be decommissioned and the site restored to as near its preconstruction condition as practicable (post-closure phase). Decommissioning and restoration of the site could have a positive effect on the setting of historic and archaeological sites and features in the surrounding area, provided that restoration works took into account historic and archaeological assets and their settings, and provided the decommissioning of the surface facilities and infrastructure did not result in the loss of any cultural heritage assets.</p> <p>Given the substantial time period that would have passed since construction, a GDF may have become part of our cultural heritage, the sphere at Dounreay being an example of this. The decommissioning of the surface facilities could therefore result in the loss of cultural heritage assets (although this would clearly depend on the cultural value placed on a GDF or its facilities).</p> <p>For all of the host rock types there would probably not be any significant difference in effects between the different waste inventories, as the surface site area for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and a similar level of closure and post-closure activity would take place on the surface.</p> <p>Similarly, there would probably not be any significant difference in effects associated with the backfilling, sealing and closure of the underground facilities and the decommissioning of the surface facilities and infrastructure between the different host rock types, as a similar level of activity would take place on the surface.</p> <p>However, following decommissioning and site restoration, the scale of any residual effect could differ between the different host rock types. Assuming that the dedicated storage area for excavated rock would be demolished as part of decommissioning for the evaporite rock type, any potential residual effect on the setting of cultural, historic and archaeological assets could be less as only the surface screening bunds would remain on-site. These could be of a smaller volume than the surface bunds for the higher strength rock and lower strength sedimentary rock types, which are assumed to comprise up to 3,589,000m³ of excavated rock.</p> <p>At this stage no site has been selected and subsequently the potential effect of closure and post-closure activities on cultural heritage and archaeology is uncertain. The potential for effects would depend on the scale and nature of the development and subsequent site restoration, the proximity of the site to any cultural historic and archaeological sites, features and landscapes, the condition and sensitivity of the site/feature/landscape affected and the level of disturbance or loss.</p>	<p>?</p>
4. Geology and Soils	<p>Decommissioning and site restoration works may have an effect on soils stored on site where they were moved or utilised for site restoration works, and for works to introduce some low level contamination (e.g. re-fuelling and oil spillages). However, any potential negative effects could be sufficiently mitigated by implementing best practice guidance on soil handling and storage. Effects could be beneficial where stored soils were used in the restoration process and restored to their condition prior to construction.</p> <p>There would probably not be any significant difference in potential effects on soils between the different waste inventories and host rock types, as the surface site area is assumed to be the same.</p> <p><i>(continued)</i></p>	<p>-</p>



Sustainability Theme	Summary of the Key Issues	Score
<p>4. Geology and Soils</p>	<p>At the closure and post-closure phase no significant effects on sites of recognised importance for their geological value (e.g. SSSI or RIGS) are anticipated, as no further surface disturbance or development would take place. However, should activities extend outside of the development footprint for the construction and operation phase there may be the potential for negative effects on such sites.</p> <p>In the case of the higher strength rock and evaporite rock types the presence of the underground facility could sterilise a mineral resource or reserve, with a GDF within the evaporite rock type potentially having the greatest effect due to the increased size of the underground facility footprint when compared to higher strength rock. Although the underground facility within lower strength sedimentary rock would have the greatest footprint, it is unlikely to have a direct effect on mineral resources or mineral reserves due to its low commercial value. However, during the operational phase in the case of the lower strength sedimentary rock type, significant quantities of bentonite would need to be imported for the backfilling of the HLW/SF disposal tunnels, which could have an effect on minerals resources and reserves elsewhere.</p> <p>As noted in the operational phase assessment, the physical presence of waste packages within the host rock would probably not have any effect on the physical stability or the background level of seismicity of the surrounding geology. There would be some risk to waste container integrity from structural failures (e.g. rock falls). However, sufficient rock support of a high standard would be provided to ensure long-term structural stability.</p> <p>Heat from the high level radioactive wastes may damage engineered barriers, backfill and host geology. However, the waste disposal areas would be designed to ensure, as far as possible, that waste temperatures did not exceed specifications. The waste packages would also be designed to ensure they retained their integrity for many hundreds of years.</p>	<p style="text-align: center;">?</p>
<p>5. Water</p>	<p>Water would be required throughout closure for routine processes (e.g. wash-down and cleaning machinery, and for domestic purposes such as toilet and washing facilities). As noted in the previous phases, water use may affect water supply, or environmental flow targets may be adversely affected. However, any closure works would be of a similar, or lesser, scale and nature as that of the proposed operational activities. Water use would also reduce as closure progressed.</p> <p>Any discharges would have the potential to affect the water quality and/or rate of flows of receiving waters. There would also be potential for contamination of surface water and groundwater through accidental spillage of materials or chemicals. However, the risk of contamination from accidental spillage would be reduced as the level of activity on site would be less.</p> <p>During closure and post-closure, surface run-off on the site would continue to be collected via the on-site drainage system and treated prior to discharge. Following decommissioning, the site would be restored to as near its preconstruction condition as practicable with a similar surface run-off regime to that originally present.</p> <p>As noted in the construction phase assessment, it is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same of that for the Derived Inventory Upper Inventory and therefore there would probably not be any significant difference in potential surface run-off and flood risk effects between the different waste inventories.</p> <p>The presence of the underground facility within the host rock, and any grouting/lining in the drift, shafts and tunnels as required, would reduce the transmissive capacity of water bearing formations (aquifers) on a localised scale, acting as a barrier to normal flow patterns.</p> <p>For all three host rock types, the potential effect of the Derived Inventory Upper Inventory on groundwater could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows.</p> <p>In the case of the higher strength and lower strength sedimentary rock types, the presence of large volumes of NRVB in the underground facility would have the potential over time to create a plume of high pH alkaline groundwater down the hydraulic gradient from the ILW/LLW vaults. For both the higher strength rock and lower strength sedimentary rock types, due to the increased size of the underground facility and associated increase in NRVB used, there would be the potential for the Derived Inventory Upper Inventory to have a greater effect on groundwater when compared to the Derived Inventory Reference Case excluding Pu/U.</p> <p><i>(continued)</i></p>	<p style="text-align: center;">-</p>



Sustainability Theme	Summary of the Key Issues	Score
<p>5. Water</p>	<p>The potential long-term effect of a GDF within higher strength rock on groundwater associated with the use of NRVB could be greater when compared to lower strength sedimentary rock, as a greater volume of NRVB would be used (for both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory). In the case of evaporite rock, the crushed rock backfill material would probably not have any long-term effects on groundwater, as crushed rock salt would be used as backfill material, which would be the same as the host rock.</p> <p>However, a GDF within lower strength sedimentary rock could potentially have the greatest effect on groundwater flows as the underground facility footprint of (7.8km² and 19.5km² for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively) would be greater when compared to higher strength rock (4.3km² and 9.8km² for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively) and evaporite rock (6.5km² and 18.4km² for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively).</p>	<p>-</p>
<p>6. Biodiversity, Flora and Fauna</p>	<p>During the closure phase the remaining underground roadways, facilities and underground access tunnels (drift and shafts in the case of higher strength rock) would be backfilled and sealed. As all surface activities associated with backfilling, sealing and closure would take place within the surface site area, no further effects on biodiversity (i.e. habitat loss due to development, habitat change and disturbance to fauna) would be anticipated to arise from land take.</p> <p>Backfilling, sealing and closure activities may disturb or displace conservation notable species from the site and its surrounds (e.g. noise, human presence and light pollution). The accidental release or spillage of substances (e.g. diesel) and silt laden run-off may also affect biodiversity. However, closure works would be of a similar, or lesser, scale and nature as that of the proposed operational activities. Given the time period that a GDF would have been in operation, there would probably not be any increase in disturbance and displacement as species in the site and the surrounds would have become accustomed to activities on site.</p> <p>Following backfilling, sealing and closure, it is assumed that the surface facilities and infrastructure would be decommissioned and the site would be restored to as near its preconstruction condition as practicable (post-closure phase). Given the substantial time period that would have passed since construction, there would be potential for negative effects where any visual screening and enhancements around the site were removed, as any planting undertaken as part of landscape and biodiversity mitigation would probably have become well established and may be of biodiversity value.</p> <p>There would probably not be any significant difference in effects between the different waste inventories and host rock types, as the surface site area and the scale of surface development would be similar and a similar level of activity would take place on the surface.</p> <p>At this stage no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the biodiversity value of the site and its surrounds, the sensitivity of any habitats/species present, and the level of habitat disturbance or loss.</p>	<p>?</p>
<p>7. Traffic and Transport</p>	<p>Closure and post-closure activities would generate traffic movements on the local road network (e.g. HGVs transporting backfill material, and personnel vehicles). Effects that could be considered as potentially significant on the road network include severance to pedestrians/cyclists induced by the flow of vehicles along a road, driver delay, pedestrian/cyclist amenity, and accidents and safety as a result of an increase in traffic.</p> <p>During closure and post-closure the greatest number of traffic movements generated would be associated with the import of mass backfill material required for backfilling the remaining underground facilities and infrastructure and the removal of waste from decommissioning surface facilities and infrastructure. However, although closure and post-closure activities would generate traffic, it is anticipated that the activities would be of a lesser scale to that during the proposed operational phase.</p> <p>For all of the host rock types the potential traffic and transport effects of closure and post-closure for the Derived Inventory Upper Inventory could be greater than those of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with a potential increase in the volume of mass backfill material required.</p> <p><i>(continued)</i></p>	<p>-</p>



Sustainability Theme	Summary of the Key Issues	Score
7. Traffic and Transport	<p>The potential traffic and transport effects that could occur would probably be the same for each of the host rock types. However, the scale of any effects could differ. For both the higher strength rock and evaporite rock types, excavated rock could meet crushed rock access tunnel (drift and/or shafts) and common services area mass backfilling requirements, which would negate the need to import any crushed rock for backfilling of these areas. In the case of the lower strength sedimentary rock, the excavated rock would not meet backfill requirements and consequently none would be used for backfilling. Therefore all mass backfill material would need to be imported to the site, which could generate a significant number of transport movements. Based on current known backfill estimates, the traffic effects of lower strength sedimentary rock could therefore be greater than that of the other host rock types. In addition, it is noted that bentonite, which would be required for mass backfilling a GDF within lower strength sedimentary rock, is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport impact.</p> <p>It should be noted that estimated quantities of backfill material required for the remaining underground roadways and facilities are not available at this stage. For the higher strength and evaporite rock types, it is unknown whether crushed rock backfill requirements for backfilling the remaining underground roadways and facilities could be met using surplus excavated rock from the construction of the underground facility. However, surplus excavated rock would remain on site in surface bunds and therefore some or all of the excavated rock may be used for this purpose.</p>	-
8. Air Quality	<p>As noted in Sustainability Theme 7 (Traffic and Transport), there would probably be an increase in traffic movements on the local road network. Exhaust emissions from traffic could lead to a decrease in local air quality, particularly from nitrogen oxides, nitrogen dioxide and particulates. Dust generated during closure and post-closure activities, particularly the movement of mass backfill material could also have an effect on local air quality if unmanaged.</p> <p>For all of the host rock types, the effect of backfilling, sealing and closure of the Derived Inventory Upper Inventory in relation to transport related air quality effects could potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with a potential increase in the volume of backfill material required.</p> <p>As noted in Sustainability Theme 7 (Traffic and Transport), based on current known backfill estimates traffic generation could be much greater for the lower strength sedimentary rock type when compared to the other host rock types, due to the requirement to import all mass backfill material. The potential transport related air quality effects could therefore potentially be greater for the lower strength sedimentary rock type. For the lower strength sedimentary rock type it is also noted that bentonite would need to be imported for the backfilling of the HLW/SF disposal tunnels. Bentonite is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport related air quality impact.</p> <p>It should be noted that estimated quantities of backfill material required for the remaining underground roadways and facilities are not available at this stage. For the higher strength and evaporite rock types it is unknown whether crushed rock backfill requirements for backfilling the remaining underground roadways and facilities could be met using surplus excavated rock from the construction of the underground facility. However, surplus excavated rock would remain on site in surface bunds and therefore there could be the potential that some or all of the excavated rock could be used for this purpose.</p>	-
9. Climate Change	<p>There would continue to be emissions of CO₂ during closure and post-closure associated with vehicle movements, diesel generators, and the energy used in facilities and infrastructure.</p> <p>It is not anticipated that closure and post-closure activities would be particularly vulnerable to the effects of climate change other than potential flooding from increased frequency and magnitude of storms if the site was located within an area at risk of flooding or surface water run-off was not managed appropriately. Changes in weather patterns as climate changes (e.g. very cold winters and hotter drier summers) would probably not affect closure and post-closure activities.</p> <p>For all of the host rock types, the effect of backfilling, sealing and closure of the Derived Inventory Upper Inventory in relation to transport related CO₂ emissions, and the carbon embodied in backfill material could potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with a potential increase in the volume of backfill material required.</p> <p><i>(continued)</i></p>	-



Sustainability Theme	Summary of the Key Issues	Score
9. Climate Change	<p>As noted in Sustainability Theme 7 (Traffic and Transport), based on current known backfill estimates traffic generation could be much greater for the lower strength sedimentary rock type when compared to the other host rock types, due to the requirement to import all mass backfill material. Transport related CO₂ emissions could therefore potentially be greater for the lower strength sedimentary rock type. In addition, in the case of lower strength sedimentary rock it is noted that bentonite would need to be imported for the backfilling of the HLW/SF disposal tunnels. Bentonite is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport related carbon emissions.</p> <p>It should be noted that estimated quantities of backfill material required for the remaining underground roadways and facilities are not available at this stage. For the higher strength and evaporite rock types, it is unknown whether crushed rock backfill requirements for backfilling the remaining underground roadways and facilities could be met using surplus excavated rock from the construction of the underground facility. However, surplus excavated rock would remain on site in surface bunds and therefore there could be the potential that some or all of the excavated rock could be used for this purpose.</p>	-
10. Noise and Vibration	<p>There would continue to be noise and vibration impacts during closure and post-closure, arising from the movement of backfill material, demolition of surface facilities and vehicle movements.</p> <p>Several activities during closure and post-closure would be sources of potential noise nuisance and disturbance. Sources of on-site noise could include earth moving equipment, backfilling activities, any demolition of surface facilities and infrastructure, and traffic. However, the majority of the backfilling activities would be undertaken at depth, with negligible surface noise disturbance. Activities such as backfilling, demolition and HGV movements may also have vibration effects. However, any vibrations are expected to be of low amplitude and short in duration.</p> <p>Noise and vibration may have an effect on sensitive receptors (occupants of residential buildings, community and recreational facilities and noise sensitive businesses and enterprises). However, whilst activities on site would generate noise and vibration, any effects from on site noise would probably not be significant due to the need to adhere to the requirements of legislation. Any noise and vibration generated during the closure and post-closure would also be less than during the construction and operational phases. However, HGV movements along the local road network may cause a local noise nuisance.</p> <p>There would probably not be any difference in noise and vibration effects between the different waste inventories and the host rock types, due to the need to adhere to the requirements of legislation.</p> <p>At this stage, no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the site and works to sensitive receptors and the level and extent of noise and vibrations generated.</p>	?
11. Land Use	<p>During the closure phase the remaining underground roadways, facilities, shafts and drift would be backfilled, sealed and closed. For the duration of these works the site would remain fenced off and inaccessible to the public, and therefore any land use effects associated with the presence of a GDF would remain.</p> <p>Following closure, the surface facilities and infrastructure would be decommissioned and the site restored to as near its preconstruction condition as practicable. Once completed, the effect and significance of site restoration would depend on site restoration and surrounding land uses. The effect would be positive where the land could be re-used for either its previous purpose (or another as appropriate), provided the land use pattern had not been affected in the long-term (i.e. there had been no change in land use surrounding the site that would affect land use within the site).</p> <p>The NDA (or its successor organisation) in consultation with the local community could specify the end state for the site (including the preferred land use) which would then determine site restoration. If the site remained unfenced or could not be re-used, the effects on land use would be extended to become longer-term or permanent. The only structures that are anticipated to remain on site are the surface bunds; therefore any land use effects associated with the presence of these bunds would remain.</p> <p><i>(continued)</i></p>	?



Sustainability Theme	Summary of the Key Issues	Score
11. Land Use	<p>For all of the host rock types there would probably not be any significant difference in effects between the different waste inventories, as the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory.</p> <p>Similarly, there would probably not be any significant difference in effects associated with backfilling, sealing and closure and the decommissioning of the surface facilities and infrastructure between the different host rock types, as a similar level of activity would take place on the surface. However, following decommissioning and site restoration, the scale of any residual effect could differ between the different host rock types. Assuming that the dedicated storage area for excavated rock would be demolished as part of decommissioning for the evaporite rock type, a greater area of the surface site area could be restored for future use, as only the surface screening bunds would remain on site. These could be of a smaller volume than the surface bunds for the higher strength and lower strength sedimentary rock types, which are assumed to comprise up to 3,589,000m³ of excavated rock.</p>	<p>?</p>
12. Socio-economics	<p>Closure and post-closure activities would generate a number of employment opportunities, a proportion of which may be suitable for the local workforce, and would support local services (e.g. garages, shops, restaurants and accommodation). The NDA estimate that, on average 379 people per year could be employed during the closure and post-closure phase, a reduction of 249 people per year compared to the operational phase. However, although activities would continue to generate employment, the scale of employment would be much lower than that during the operational phase, with the potential for job losses of both operational staff and closure staff where they are no longer required. Employment would probably continue to decrease as decommissioning progressed. Notwithstanding this, plans would need to be put in place to retain staff or help them find alternative employment. The community benefits package may also provide a number of on-going benefits following the closure of the facility.</p> <p>Following completion of the site restoration the majority of staff employed at a GDF, with the exception of those professional staff involved in post site restoration maintenance, would no longer be employed. This could have a significant negative effect on employment in the local area with significant effects on the local economy.</p> <p>The closure of a GDF may affect supply chains and local prices due to the requirement for significant volumes of backfill material. The effect would depend on the availability and demand for resources. Due to the requirement to import significant volumes of mass backfill material, the lower strength sedimentary rock type may have a greater effect on supply chains. The higher strength rock and evaporite rock types present greater opportunities for excavated rock use on site, reducing the potential effect of these host rock types on supply.</p> <p>Depending on the location of a GDF and the proximity of local populations, there may be a negative effect on quality of life from closure activities (e.g. associated with traffic on the road network, noise and air quality effects from works and traffic). However, the works would be of a similar, or lesser, scale and nature as that of the proposed operational activities and therefore there it is not anticipated that there would be any increase in effects. Any effects on quality of life would reduce as closure progresses.</p> <p>The continued presence of the underground facility may have a negative impact on the desirability of the surrounding area as a place to live, work and invest, with potential for negative effects on local land values and house prices.</p> <p>At this stage, no site has been selected and subsequently the potential for effects on quality of life and desirability is uncertain. The potential for effects would depend on the proximity of the site and construction works to sensitive receptors and the level and extent of any disturbance.</p>	<p style="text-align: center; vertical-align: middle;">+</p> <p style="text-align: center; vertical-align: middle;">?</p>



Sustainability Theme	Summary of the Key Issues	Score
13. Health and Well-Being	<p>Closure and post-closure activities may have a negative effect on health and well being (e.g. disturbance from noise and vibrations, and air quality effects from works and traffic). However, the works would be of a similar, or lesser, scale and nature compared to operational activities and any effects on health and well-being would probably reduce as closure progressed. The majority of the activities would also be undertaken at depth. There may also be some beneficial effects on health and well-being through the continued application of a community benefits package.</p> <p>In the long-term, there could be concerns regarding health and safety associated with the presence of radioactive waste in the underground facility. Perceived risks associated with the presence of the underground facility may cause concern, which could affect people's health and well-being (e.g. increased/elevated stress levels). Consideration of radiological effects is outside the scope of this assessment. However, the facility would be designed to meet regulatory requirements with regard to the protection of the environment and the public from radiological hazards.</p> <p>At this stage no site has been selected and subsequently the potential for effects on health and well-being is uncertain. This depends on the proximity of the site to sensitive receptors and the extent of any disturbance.</p>	<p>?</p>
14. Safety	<p>Closure and post-closure activities would present a risk to human health and safety. Potential major hazards include: collision and impact hazards (e.g. involving plant, vehicles and personnel); exposure to substances hazardous to health (e.g. contact with cement, dusts etc); entrapment, asphyxiation, and loss of ventilation (e.g. associated with underground works); electrical hazards (e.g. electrical shock from live cables); and other occupational hazards such as working at height and manual handling.</p> <p>Closure and post-closure activities would probably not present a significant risk to the public (i.e. local communities) provided access to the site was restricted and the relevant health and safety procedures were in place. Although traffic movements on the local road network could potentially increase the risk of road traffic accidents.</p> <p>However, although there would be many potential risks during closure and post-closure, it is assumed that any risk would have been identified and managed through the contractor(s)/operator(s) compliance with health and safety legislation and risk management procedures. The staff working on site would be professionals and would be unlikely to experience any greater risk to safety than at other work locations. Members of the public would not normally be allowed on site. As such, the potential effects would probably not be significant.</p> <p>A GDF and associated transport infrastructure would be designed to meet regulatory requirements with regard to the protection of the environment and public from radiological hazards. The level of protection would be consistent with the national standard at the time of waste disposal.</p> <p>Taking account of health and safety regulations, it is assumed that the level of closure and post-closure activity taking place would not vary, and therefore there would not be a significant difference in potential safety effect between the different waste inventories and host rock types. However, the length of time involved may increase the statistical chance of accidents occurring.</p>	<p>-</p>
15. Waste	<p>During the closure and post-closure phase, a range of construction and general office waste arisings would be generated, including some potentially hazardous or special waste material. Key waste arisings are anticipated to include waste backfill material and waste building materials from decommissioning and/or demolition of the surface buildings and infrastructure such as concrete, bricks/blocks, tiles, woods, metals and plastics. Other wastes could include packaging, nails/bolts, worn tools, canisters, drums (e.g. fuel, diesel, chemicals) and food waste and food packaging from on-site food consumption. It is also expected that there would be some general office waste arisings such as paper, organic canteen waste and packaging. Some of the waste may be treated as special or hazardous waste and would need to adhere to relevant waste guidance.</p> <p>The potential effect of the Derived Inventory Upper Inventory in relation to waste could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of a GDF, with a potential increase in the volume of backfill material required and subsequent waste generated.</p> <p>The extent of waste arisings would probably vary between the different host rock types. However, as specific quantities of backfill material and waste arisings are unknown, the extent of any potential differences is unknown.</p>	<p>-</p>



Sustainability Theme	Summary of the Key Issues	Score
<p>16. Resource Use, Utilities and Services</p>	<p>During the closure and post-closure phase, significant quantities of backfill material would be required for mass backfilling of the underground facilities and roadways.</p> <p>Key utilities and services that would be required during closure and post-closure include electricity, water supplies, communications systems, and ventilation systems for works underground.</p> <p>Throughout closure and post-closure there would be energy use associated with the operation of plant machinery and equipment, site buildings and infrastructure (heating, lighting, canteen facilities, electronics etc), the operation of ventilation systems to ensure a supply of clean air, and lighting to allow safe working and for security purposes. Diesel generators may be used as the primary source of electricity if suitable means of connection do not exist, or the local mains supply is deemed unreliable.</p> <p>Water would be required throughout closure and post-closure for routine processes such as wash-down and decontamination; and for domestic purposes such as drinking water, canteen use and toilet and washing facilities. In addition, a reliable and adequate water storage and distribution system would be required for fire. Sewerage systems for treatment of wastewater may also be required, depending on whether there is opportunity to connect to the existing network.</p> <p>However, the level of utilities and services use during closure would probably be less than that during construction and operation, and would probably reduce as the works progressed.</p> <p>For all of the host rock types, the effect of the Derived Inventory Upper Inventory could potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of a GDF, with an associated increase in resource use (particularly backfill materials).</p> <p>Although the types of resources, utilities and services would be similar for the different host rock types, the extent of resource use would probably vary between the different host rock types. Estimates of the quantities of mass backfill materials required for the backfilling of the remaining underground roadways and facilities are not currently available. Notwithstanding this, for both the higher strength and evaporite rock types, excavated rock from the construction of the underground facilities which would be stored on site could meet crushed rock access tunnel (drift and/or shafts) and common services area backfilling requirements, which would negate the need to import any crushed rock for backfilling of these areas.</p> <p>In the case of the higher strength rock and evaporite rock types, it is unknown whether crushed rock backfill requirements for backfilling the remaining underground roadways and facilities could be met using surplus excavated rock from the construction of the underground facility. However, surplus excavated rock would remain on site in surface bunds and therefore some or all of the excavated rock could be used for this purpose. In the case of the lower strength sedimentary rock, the excavated rock would not meet backfill requirements and consequently none would be used for backfilling. Therefore, all backfill material would need to be imported to the site. Mass backfill material resource requirements could therefore potentially be greater for the lower strength sedimentary rock type when compared to the other host rock types. It is noted that bentonite required for mass backfilling for the lower strength sedimentary rock type is not widely available in the UK and therefore may need to be shipped from abroad.</p>	<p>-</p>



4.6 Summary of the key effects

Tables 4.7 to Table 4.10 summarise the key effects of the illustrative geological disposal concepts for each host rock type against each sustainability theme across the four phases. The cumulative effects of the differing phases are shown in **Table 4.11**.

Broadly, the nature of the effects would be very similar for each host rock type, although the scale and significance of the effect for the different host rock types would vary.

As outlined in **Section 3.5**, a six point qualitative colour coded scoring system has been used to assess the effects of the illustrative geological disposal concepts, which provides a graphical indication of the magnitude of the effects predicted.

Table 4.5 Qualitative scoring system

Score	Description	Symbol
Major positive effect	The illustrative geological disposal concept contributes significantly to the achievement of the objective,	++
Minor positive effect	The illustrative geological disposal concept contributes to the achievement of the objective but not significantly.	+
Neutral / negligible	The illustrative geological disposal concept does not have any positive or negative effects on the achievement of the objective.	0
Minor negative effect	The illustrative geological disposal concept detracts from the achievement of the objective but not significantly	-
Major negative effect	The illustrative geological disposal concept detracts significantly from the achievement of the objective.	--
Uncertain	The illustrative geological disposal concept has an uncertain relationship with the objective or the relationship is dependant on the way in which the issue is managed. In addition, insufficient information may be available to enable an assessment to be made.	?

In addition, for the purposes of comparing the different host rock types and the different waste inventories, shading and symbols have been used in **Tables 4.7 to Table 4.11** to highlight where the potential effects could be greater, as outlined in the key below.



Table 4.6 Key to Tables 4.7 to 4.11

>	<p>Comparison of the different host rock types</p> <p>Where a > symbol is shown, the potential effect of the indicated host rock type could be greater when compared to the other host rock types. Where there are no > symbols against a sustainability theme, there would probably not be any significant difference in effect between the different host rock types.</p> <p>Refer to the commentary within Tables 4.7 to Table 4.10 for details.</p>
*	<p>Comparison of the different waste inventories (Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory)</p> <p>Where a * symbol is shown, the potential effect of the indicated waste inventory could be greater when compared to the other waste inventory. Where there are no * symbols against a sustainability theme, there would probably not be any significant difference in effect between the different waste inventories.</p> <p>Refer to the commentary within Tables 4.7 to Table 4.10 for details.</p>



Table 4.7 Summary of effects for the surface-based site investigations phase (for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory)

Site investigation phase							
Sustainability Theme	Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Summary of the key effects
	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	
1. Policies and Planning	+	+	+	+	+	+	<p>Potential positive effects</p> <p>The site investigations would help to ensure the selection of an appropriate site for the development of a GDF, thus contributing positively towards fulfilling policy and legislative commitments for the safe long-term management of radioactive wastes.</p> <p>Employee opportunities could be generated, a proportion of which may be available to local people, and could benefit the local economy (e.g. through increased use of garages, shops and accommodation). However, whilst positive, any benefits are unlikely to be significant due to the scale and temporary nature of employment created and the specialist nature of the works.</p> <p>Potential negative effects</p> <p>Drilling campaigns could have a negative effect on resources (soil, water, energy and materials), would generate wastes, and could also have a negative visual effect.</p> <p>In addition, there would be an increase in traffic, with associated air quality and climate change effects. Depending on the site, there may also be negative effects on cultural heritage, biodiversity, the local community and businesses.</p> <p>There is the potential for borehole drilling campaigns to affect sites of recognised importance for their geological value (e.g. SSSI or RIGS). Such effects would be site specific and therefore are uncertain.</p> <p>In the case of the higher strength rock and evaporite rock types, drilling campaigns may result in the temporary sterilisation of mineral resources/reserves. This would be unlikely in the case of the lower strength sedimentary rock type as its commercial value would be low.</p> <p>Comparison of different waste inventories</p> <p>There would probably not be any difference in effects between the different waste inventories, as the site investigation works would be of a similar scale in each case.</p> <p>Comparison of different host rock types</p> <p>With the exception of potential effects on minerals, there would no discernable differences between the different host rock types as the site investigations would be similar for each host rock type.</p> <p>The effects identified for the site investigation works would probably be an order of magnitude less than the effects for the other programme phases. They would be of a relatively small scale and spread over a number of years, with the main effects at any one borehole site being felt for a few months only.</p>
2. Landscape and Visual	-	-	-	-	-	-	
3. Cultural Heritage	?	?	?	?	?	?	
4. Geology and Soils	>	>	-	-	>	>	
5. Water	-	-	-	-	-	-	
6. Biodiversity, Flora and Fauna	?	?	?	?	?	?	
7. Traffic and Transport	-	-	-	-	-	-	
8. Air Quality	-	-	-	-	-	-	
9. Climate Change	-	-	-	-	-	-	
10. Noise and Vibration	?	?	?	?	?	?	
11. Land Use	-	-	-	-	-	-	
12. Socio-economics	+	+	+	+	+	+	
	?	?	?	?	?	?	
13. Health and Well-being	?	?	?	?	?	?	
14. Safety	-	-	-	-	-	-	
15. Waste	-	-	-	-	-	-	
16. Resource Use, Utilities and Services	-	-	-	-	-	-	



Table 4.8 Summary of effects for the construction phase (for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory)

Construction phase							
Sustainability theme	Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Summary of the key effects
	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	
1. Policies and Planning	+	+	+	+	+	+	<p>Potential positive effects</p> <p>The construction of a GDF would fulfil policy and legislative commitments for the long-term management of radioactive wastes. However, it could be associated with a significant carbon footprint, which if not offset by corresponding reductions elsewhere in the UK economy could detract from the UK meeting its obligations under the Climate Change Act 2008.</p>
2. Landscape and Visual	> -	> -	> -	> -	-	-	<p>Construction would generate significant employment, a proportion of which may be available to local people, and could benefit the local economy (e.g. through increased use of garages, shops, accommodation etc). A community benefits package would also have a positive effect.</p>
3. Cultural Heritage	> ?	> ?	> ?	> ?	?	?	<p>Potential negative effects</p> <p>There would probably be a number of detrimental effects, arising particularly from the construction of the surface facilities and infrastructure, and from the excavation and storage of rock from the construction of underground facilities. All of the host rock types score negatively in relation to transport, climate change, waste and resource use, due to the significant volumes of excavated rock and other wastes which would be exported from the site, and/or construction material that would be imported to the site.</p>
4. Geology and Soils	- ?	-* ?	- ?	-* ?	- ?	-* ?	<p>Construction of the surface facilities and infrastructure, and the storage of excavated rock could also have a negative effect on land uses due to the land take required, and could have a negative landscape and visual effect. In addition, depending on the location of the site, surface activities may negatively affect cultural heritage, biodiversity and the local community.</p>
5. Water	-	-*	> -	> -*	-	-*	<p>Comparison of different waste inventories</p> <p>For all host rock types, in the majority of cases, the effect of the Derived Inventory Upper Inventory could be greater, due to the increased size of underground facility, with an associated increase in timescales, volume of rock affected, materials required, waste generated, and surplus excavated rock to be removed off-site.</p>
6. Biodiversity, Flora and Fauna	> ?	> ?	> ?	> ?	?	?	<p>Comparison of different host rock types</p> <p>Construction of a GDF within the higher and lower strength sedimentary rock types may have a greater effect on environmental assets (landscape, cultural heritage, biodiversity and land use) depending on the level of surface disturbance. Although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site in the case of the evaporite rock type, surface disturbance could be less. However, the potential difference in effect on such assets would probably not be significant.</p>
7. Traffic and Transport	> :-	> :-*	-:-	-:-*	-:-	-:-*	
8. Air Quality	> -	> -*	-	-*	-	-*	



Construction phase							
Sustainability theme	Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Summary of the key effects
	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	
9. Climate Change	--	--*	--	--*	--	--*	<p>Comparison of different host rock types (continued)</p> <p>The construction of a GDF could affect sites of recognised importance for their geological value (e.g. SSSI or RIGS). In the case of the higher strength rock and evaporite rock types, construction of a GDF may also result in the sterilisation of mineral resources/reserves, a GDF within evaporite rock potentially having the greatest effect when compared to higher strength rock due to it having a larger underground facility footprint. However, for both host rock types a proportion of the excavated rock would be used for backfilling the vaults. This would negate the need to import any crushed rock for backfilling, which could otherwise affect mineral resources supply elsewhere. The potential also exists for the beneficial use of the remainder of excavated rock to be removed off-site. Although the underground facility within lower strength sedimentary rock would have the greatest underground facility footprint of all of the host rock types, it is unlikely to have a direct effect on mineral resources/ reserves due to its low commercial value.</p> <p>Due to the increased size of the lower strength sedimentary rock underground facility footprint when compared to the other host rock types, its construction could have a greater effect on groundwater. In the case of lower strength sedimentary rock and evaporite rock (depending upon its type), there would also be the potential for excavated rock to negatively affect water quality. Lower strength sedimentary rock may contain sufficient sulphide to cause acid generating reactions, and the evaporite rock type halite is highly soluble in fresh water. The evaporite rock anhydrite, however, is less soluble.</p> <p>The lower strength sedimentary rock type could have the greatest effect in relation to waste arisings, as opportunities for the beneficial re-use of any surplus excavated rock could be limited due to its low commercial value. In the case of lower strength sedimentary rock greater volumes of waste excavated rock could therefore be generated.</p> <p>Construction of a GDF within higher strength rock may give rise to more significant effects on traffic and air quality when compared to the other host rock types due to the need to import greater quantities of construction materials to the site via road (taking account of the transport of materials for the construction of the surface-based facilities, underground accesses, common services area and ILW/LLW vaults and HLW/SF disposal tunnels).</p> <p>CO₂ emissions associated with the transport of construction materials to site by road are estimated to be greatest for higher strength rock, due to the greater volumes of construction materials required compared to the other host rock types.</p> <p>With respect to embodied carbon (associated with the surface based facilities, waste disposal areas and common services area), the higher strength rock type could potentially have a more significant effect when compared to the other host rock types.</p>
10. Noise and Vibration	?	?	?	?	?	?	
11. Land Use	> -	> -*	> -	> -*	-	-*	
12. Socio-economics	++	+++	++	+++	++	+++	
	?	?*	?	?*	?	?*	
13. Health and Well-being	?	?*	?	?*	?	?*	
14. Safety	-	-*	-	-*	-	-*	
15. Waste	--	--*	> --	> --*	--	--*	
16. Resource Use, Utilities and Services	> --	> --*	--	--*	--	--*	



Table 4.9 Summary of effects for the operation phase (for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory)

Operation phase							
Sustainability theme	Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Summary of key effects
	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	
1. Policies and Planning	+	+	+	+	+	+	<p>Potential positive effects</p> <p>As per construction, the operation of a GDF would fulfil policy and legislative commitments for the long-term management of radioactive wastes. However, it could be associated with a significant carbon footprint, which if not offset by corresponding reductions elsewhere in the UK economy could detract from the UK meeting its obligations under the Climate Change Act 2008.</p>
2. Landscape and Visual	> -	> -	> -	> -	-	-	<p>The operation of a GDF would generate employment and continue to support local services. A community benefits package would also continue to have a positive effect. However, there would be a reduction in employment from the construction phase.</p>
3. Cultural Heritage	?	?	?	?	?	?	<p>Potential negative effects</p> <p>Once a GDF becomes operational, the construction of the surface facilities and infrastructure would have been completed, so there would probably not be any further significant landscape and visual, cultural heritage and biodiversity effects. However, any visual effect of the surface facilities and infrastructure, and effects on land uses would remain and there may be continued disturbance to biodiversity (flora and fauna) in the site and surrounds.</p>
4. Geology and Soils	-	-*	-	-*	-	-*	<p>Construction of the waste disposal areas would be ongoing throughout the operational phase, excavated as required for waste emplacement. There would be continued negative effects in relation to geology, transport, climate change, waste and resource use, due to the significant volumes of surplus excavated rock and other wastes to be removed off-site, and construction, and buffer/backfill material to be imported to site.</p>
5. Water	-	-*	> -	> -*	-	-*	<p>Comparison of different waste inventories</p> <p>For all host rock types the potential effect of the Derived Inventory Upper Inventory could be greater than that of the Derived Inventory Reference Case excluding Pu/U, due to the increased size of the facility, with an associated increase in timescales, volume of rock affected, construction, and buffer/backfill materials required, waste generated, and increase in excavated rock to be removed off-site.</p>
6. Biodiversity, Flora and Fauna	> ?	> ?	> ?	> ?	?	?	<p>Comparison of different host rock types</p> <p>A GDF within the higher strength rock and evaporite rock types could result in the sterilisation of mineral resources/reserves, with the evaporite rock type potentially having the greatest effect due to its larger underground facility footprint compared to higher strength rock. However, for both host rock types a proportion of the excavated rock would be used for backfilling. This would negate the need to import crushed rock for this purpose, which could otherwise affect minerals supply elsewhere. The potential also exists for the beneficial use of the remainder of excavated rock removed off-site.</p>
7. Traffic and Transport	> -	> -*	-	-*	-	-*	
8. Air Quality	> -	> -*	-	-*	-	-*	



Operation phase							
Sustainability theme	Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Summary of key effects
	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	
9. Climate Change	--	--*	--	> --*	> --	--*	<p>Although the underground facility for the lower strength sedimentary rock type would have the greatest footprint, this would probably not have a direct effect on mineral resources or mineral reserves due to its low commercial value. However, during the operational phase in the case of the higher strength and lower strength sedimentary rock types, significant quantities of bentonite would need to be imported for backfilling, which could have an effect on minerals resources and reserves elsewhere. The potential effect associated with the import of bentonite could be greater for the higher strength rock type than that of lower strength sedimentary rock, as a greater quantity of bentonite would be required for this purpose.</p> <p>As noted in the construction phase, due to the increased size of the lower strength sedimentary rock underground facility footprint compared to the other host rock types, its construction could result in a greater effect on groundwater. In addition, in the case of lower strength sedimentary rock and evaporite rock (depending upon its type), there would also be the potential excavated rock to negatively affect water quality if it came into contact with water.</p> <p>The lower strength sedimentary rock type would continue to have the greatest effect in relation to waste arisings during the operational phase, due to there being fewer potential opportunities for re-use of any surplus excavated rock arising from the continued construction of the waste disposal areas.</p> <p>During operation the higher strength rock type could have a more significant effect on traffic and air quality when compared to the other host rock types due to the need to import greater quantities of buffer/backfill materials to the site via road.</p> <p>There would not be any difference in effects associated with the transport of radioactive waste between the different host rock types, as all would be designed to accept the same volumes. However, the CO₂ emissions associated with the transport of radioactive waste by rail (the Road/Rail scenario, which assumes a 70:30 rail and road split) are estimated to be greater than if radioactive waste is transported predominantly by sea (the Sea/Road/Rail scenario, which assumes a 80:10:10 sea, rail and road split).</p> <p>Overall for the construction and operational phase, based on CO₂ emissions estimates for the Derived Inventory Reference Case the evaporite rock type would probably generate the greatest amount of transport related CO₂ emissions, as although fewer construction and buffer/backfill materials would be required when compared to the other host rock types, a significantly greater volume of surplus excavated rock would need to be removed off-site.</p> <p>For the Derived Inventory Upper Inventory the lower strength sedimentary rock type could generate the greatest amount of transport related CO₂ emissions, due to the volume of surplus excavated rock to be removed off-site and construction materials and buffer/backfill materials to be transported to the site.</p>
10. Noise and Vibration	?	?	?	?	?	?	
11. Land Use	> -	> --*	> -	> --*	-	--*	
12. Socio-economics	+	++	+	++	+	++	
	?	?*	?	?*	?	?*	
13. Health and Well-being	?	?*	?	?*	?	?*	
14. Safety	-	--*	-	--*	-	--*	
15. Waste	--	--*	> --	> --*	--	--*	
16. Resource Use, Utilities and Services	> --	> --*	--	--*	--	--*	



Operation phase							
Sustainability theme	Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Summary of key effects
	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	
16. Resource Use, Utilities and Services	∨ ∴	∨ ∴*	∴	∴*	∴	∴*	During operation, resource use could be greater for the higher strength rock type, due to the need to import greater volumes of buffer/backfill material when compared to the other host rock types. It is noted in the case of the higher strength rock and lower strength sedimentary rock types that bentonite, required for buffer/backfilling, is not widely available in the UK and therefore may need to be shipped from abroad.



Table 4.10 Summary of effects for the closure and post-closure phase (for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory)

Closure and post-closure phase							
Sustainability theme	Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Summary of key effects
	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	
1. Policies and Planning	?	?	?	?	?	?	<p>By the closure and post-closure stage, given the timescales involved and that a site location is not known at this stage, many of the potential effects have been identified as uncertain, although the potential for both adverse and beneficial effects has been noted. At closure and post-closure, it is anticipated that, in general terms, the magnitude and significance of effects, where identified, would decrease in most cases when compared to the construction and operational phases.</p> <p>Potential positive effects</p> <p>Given the substantial time period that would have passed by the time a decision is reached to close a GDF, the potential effect of this phase in relation to policies and planning is uncertain.</p> <p>Closure and post-closure activities would generate employment opportunities. However, the scale of employment would be much lower (a reduction of an estimated 249 posts) than that during the operational phase, with the potential for job losses of both operational staff and closure staff when they are no longer required.</p> <p>Potential negative effects</p> <p>Employment would continue to decrease as decommissioning progressed. Following completion of the site restoration, the majority of staff employed at a GDF, with the exception of those professional staff involved in post site restoration maintenance, would no longer be employed. Compared to the previous stages of GDF development, this could have a significant negative effect on employment in the local area, with significant effects on the local economy due to the loss of income and GDF expenditure.</p> <p>During backfilling, sealing and closure of the underground facility and the decommissioning of surface facilities and infrastructure, the works could continue to affect environmental assets and local communities (e.g. residents).</p> <p>The potential effects of site restoration on the landscape, cultural heritage, biodiversity and land uses are uncertain. The nature of the effects would depend on the site restoration works undertaken, i.e. whether the site were restored to its previous land use, whether opportunities for enhancements were pursued and whether the site became available for other uses.</p> <p>The closure and post-closure activities would probably continue to have a negative effect in relation to traffic, waste and resource use, due to the import of significant volumes of backfill material to the site and the removal of waste from the site, with associated air quality and climate change effects.</p>
2. Landscape and Visual	> ?	> ?	> ?	> ?	?	?	
3. Cultural Heritage	> ?	> ?	> ?	> ?	?	?	
4. Geology and Soils	-	-	>	>	>	>	
5. Water	> *	>	>	> *	-	-	
6. Biodiversity, Flora and Fauna	> ?	> ?	> ?	> ?	?	?	
7. Traffic and Transport	-	-*	>	> *	-	-*	
8. Air Quality	-	-*	>	> *	-	-*	



Closure and post-closure phase							
Sustainability theme	Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Summary of key effects
	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	
9. Climate Change	-	-*	>	>*	-	-*	<p>For the higher and lower strength sedimentary rock types, there would be potential for NRVB to create a plume of high pH alkaline groundwater over time due to its lime content. The potential long-term effect on groundwater associated with the use of NRVB could be greater for the higher strength rock type when compared to lower strength sedimentary rock, as a greater volume of NRVB would be used. In the case of the evaporite rock type, the crushed rock backfill material would not have any long-term effects on groundwater, due to it being the same as the host rock.</p> <p>Comparison of different waste inventories</p> <p>For all host rock types, in the majority of cases, the potential effect of the Derived Inventory Upper Inventory could be greater than that of the Derived Inventory Reference Case excluding Pu/U, due to the increased size of the underground facility, with an associated increase in timescales, backfill materials required and waste generated.</p> <p>Comparison of different host rock types</p> <p>Based on current known backfill estimates, the lower strength sedimentary rock type could give rise to more significant effects during the closure and post-closure phase, due to the need to import all backfill material. For both the higher strength rock and evaporite rock types, excavated rock could meet crushed rock drift and/or shafts and common services area backfill requirements, negating the need to import crushed rock for backfilling of these areas. For the higher strength rock and evaporite rock types, it is unknown whether crushed rock requirements for backfilling the remaining underground roadways and facilities could be met using surplus excavated rock from the construction of the underground facility. However, surplus excavated rock would remain on site in surface bunds and some or all of the excavated rock could be used for this purpose. In the case of the lower strength sedimentary rock type, as all backfill material would need to be imported to the site this could result in a greater number of transport movements, with associated secondary effects on air quality and climate change, resource use and markets/supply chains. It is also noted that bentonite, which would be used for mass backfilling for the lower strength sedimentary rock type, is not widely available in the UK and therefore bentonite may need to be shipped from abroad.</p> <p>Following decommissioning and site restoration, the scale of any residual effects at surface could differ between the different host rock types. Assuming that a dedicated storage area for excavated rock would be demolished as part of decommissioning, any potential residual landscape and visual and land use effect could be less for the evaporite rock type as only the surface screening bunds would remain on site. These could be of a smaller volume than the surface bunds for the higher strength and lower strength sedimentary rock types, which are assumed to comprise up to 3,589,000m³ of excavated rock.</p>
10. Noise and Vibration	?	?	?	?	?	?	
11. Land Use	> ?	> ?*	> ?	> ?*	?	?*	
12. Socio-economics	+	+	+	+	+	+	
	?	?*	?	?*	?	?*	
13. Health and Well-being	?	?	?	?	?	?	
14. Safety	-	-*	-	-*	-	-*	
15. Waste	-	-*	-	-*	-	-*	
16. Resource Use, Utilities and Services	-	-*	>	>*	-	-*	



Table 4.11 Summary of effects (for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory)

Implementation phase	Surface-based Site Investigations						Construction						Operation						Closure and post-closure						
	Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Higher strength rock		Lower strength sedimentary rock		Evaporite rock		
	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	
1. Policies and Planning	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	?	?	?	?	?	?
2. Landscape and Visual	-	-	-	-	-	-	>	>	>	>	-	-	>	>	>	>	-	-	>	>	>	>	?	?	
3. Cultural Heritage	?	?	?	?	?	?	>	>	>	>	?	?	?	?	?	?	?	?	>	>	>	>	?	?	
4. Geology and Soils	-	-	-	-	-	-	-	*	-	*	-	*	-	*	-	*	-	*	-	-	>	>	>	>	
	?	?	?	?	?	?	?	?	>	>	?	?	?	?	>	>	?	?	?	?	?	?	?	?	
5. Water	-	-	-	-	-	-	-	*	>	>	-	*	-	*	>	>	-	*	>	>	>	>	-	-	
6. Biodiversity, Flora and Fauna	?	?	?	?	?	?	>	>	>	>	?	?	>	>	>	>	?	?	>	>	>	>	?	?	
7. Traffic and Transport	-	-	-	-	-	-	>	>	>	>	-	*	>	>	>	>	-	*	-	*	>	>	-	*	
8. Air Quality	-	-	-	-	-	-	-	*	-	*	-	*	>	>	-	*	-	*	-	*	>	>	-	*	



Implementation Phase	Surface-based Site Investigations						Construction						Operation						Closure and post-closure							
	Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Higher strength rock		Lower strength sedimentary rock		Evaporite rock		Higher strength rock		Lower strength sedimentary rock		Evaporite rock			
	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory	Reference Case	Upper Inventory		
9. Climate Change	-	-	-	-	-	-	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*
10. Noise and Vibration	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
11. Land Use	-	-	-	-	-	-	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*
12. Socio-economics	+	+	+	+	+	+	++	++	++	++	++	++	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
13. Health and Well-being	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
14. Safety	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15. Waste	-	-	-	-	-	-	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*
16. Resource Use, Utilities and Services	-	-	-	-	-	-	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*	-	-*

(Note: the magnitude of predicted effects is not directly comparable between implementation phases – see summary text in Tables 4.7 to 4.10)



4.7 Key mitigation measures/enhancements

Measures have been identified in the assessment that could be used to address the potential adverse effects identified or to enhance the potential positive effects associated with GDF implementation. These could be incorporated into future design iterations for a GDF and/or be taken into consideration during the site selection process. The key mitigation measures/enhancements identified are set out in **Table 4.12**.

Table 4.12 Key mitigation and enhancement measures

Mitigation and enhancement measures	
Surface-based site investigations	
Design and Location	<p>Policies and Planning:</p> <p>It has been assumed that all works would adhere to relevant legislation and best practice guidance. Where possible minimum requirements should be exceeded as should any conditions relating to planning permission for the works.</p> <hr/> <p>Landscape and Visual:</p> <p>At an early stage following site selection and prior to any works, consideration needs to be given to the receiving environment and sensitivity of receptors, and the potential effects on key views and designated landscape areas. This would enable appropriate measures to be designed and implemented to have maximum impact in terms of reducing any negative effects.</p> <p>The loss of existing landscape elements such as woodland, trees, hedgerows and other planting should be avoided where possible through the careful siting and layout of drilling rigs and associated features. Where vegetation within the site(s) is of value, it should be retained where possible.</p> <p>Negative effects from the introduction of new visual elements may be reduced by the use of appropriate siting and screening of infrastructure (through the use of existing woodlands or copses or temporary earth mounds using spoil and suitable grass seed mixes).</p> <p>Buildings and infrastructure should be of a high quality design with due consideration given to the aesthetics in relation to existing local colours and architectural styles. The size of buildings should be kept to a practical minimum.</p> <p>The colour and texture of surfaces should be considered and attempts should be made to minimise contrast with the landscape. Visual intrusion may be mitigated through the use of appropriate hardstanding materials (e.g. local crushed stone).</p> <p>The use of fluorescent lighting should be minimised where possible to prevent overspill, glare and light pollution. The number and height of lighting poles should be reduced to a practicable minimum and directional shields used to control light spillage.</p> <p>Any spoil mounds should be of a scale that is characteristic of the local landscape (e.g. in terms of topography and vegetation). In order to establish vegetation on spoil mounds, it would be necessary to provide some form of growing medium to support plant growth. This would require consideration of the likely availability of soils. Emerging research from WRAP identifies a method of producing topsoil from a mixture of waste aggregate and compost. This method also provides a means of recycling aggregates from the site (http://www.wrap.org.uk/downloads/Soil_Matters.7723a430.7363.pdf).</p> <p>It may be appropriate to form several screening mounds at different distances from security fences to reflect the landscape character of the site and surrounding area. The ends of these mounds should overlap to maintain a continuous screen around the site. The mound may also be developed in stages, targeting the views of construction works from key visual receptors first.</p>



Mitigation and enhancement measures

Design and Location (cont)

There is the potential to minimise the negative effect of access roads by linking to the existing road network at the closest point or by linking a number of drilling pads together, rather than linking each directly to the existing road network. The effects on the landscape of the access roads may be mitigated by ensuring that their layout corresponds with natural linear landscape patterns or by being located at the bottom of valleys.

Following completion of the surface-based site investigations, the sites should be restored to their former land use. Any landscape features lost as part of the works (e.g. trees or hedgerows) should be replanted on a like for like basis to the same or enhanced quality, with maintenance carried out for a sufficient time to allow any habitat to establish.

There may be opportunities to gather information on landscape character as part of the regional surveys (e.g. ground and aerial surveys could be used to inform landscape characterisation or to aid in the identification and mapping of landscape features). Any opportunities for increased learning during the site investigation works should be pursued.

Cultural Heritage:

It is anticipated that any significant detrimental effects arising from site investigation works on cultural heritage and archaeology, including subsurface and buried archaeology and traditional activities, may be minimised through early liaison with, and adhering to guidance issued by English Heritage, the National Trust and other appropriate organisations.

At an early stage following site selection and prior to any works on site, a desk study and site walkover should be undertaken to determine the historic and archaeological value of the site and the subsequent need for further site evaluation (such as trial trenching, or more specific geophysical surveys).

Where necessary and possible, the construction methodology (e.g. foundation design) should be altered in order to minimise effects on historic or archaeological features, or features retained in situ. If retention of any features is not possible, consideration should be given to moving features to another location or storage, or detailed excavation and recording of the affected feature should be undertaken.

A watching brief is recommended during topsoil stripping and excavation works in order to identify any unexpected features or artefacts arising during the works. Where features may be affected, the use of angled drilling should be considered if appropriate.

Identifying appropriate routes to access the site would help to minimise potential negative effects on historic or archaeological features (e.g. listed buildings) caused by transport pollution and vibration.

Where there is the potential for adverse effects on the setting of cultural heritage and archaeological sites and features, surface infrastructure should be appropriately sited to reduce any effect and the footprint of the works minimised as far as practically possible.

There may be opportunities to gather information on cultural heritage and archaeology as part of the regional surveys (e.g. ground and aerial surveys could be used to inform landscape characterisation or to aid in the identification and mapping of features and assets). Any opportunities for increased learning during the site investigation works should be pursued.

Geology and Soils:

Activities that may affect directly or indirectly any geological features of value (e.g. SSSIs or RIGS) should be avoided, unless no other suitable location can be identified.

At an early stage following site selection and prior to any works on site, surveys should be undertaken to identify different soil materials on the site.

The site should be carefully stripped of top soil prior to construction works commencing to avoid damage. All soils should be handled in suitable conditions (e.g. dry weather) and the most appropriate method of soil handling should be used. Soils should be stored in allocated heaps and protected from erosion, contamination or degradation. Different soil types should be stored separately and the length of time soils are stored should be minimised where possible.



Mitigation and enhancement measures

Design and Location (cont)

Soil excavation and mounds should avoid compaction where possible by making use of appropriate wide tracked vehicles and avoiding working on soil when it is wet. Appropriate drainage systems should be utilised on site to reduce soil erosion. Spoil mounds should be shaped to shed rainwater. A suitable grass seed mix could be used to provide a vegetation cover and reduce the risk of soil erosion from surface run-off.

Opportunities for the beneficial re-use of drilling cuttings should be explored (e.g. re-use of cuttings as a secondary aggregate). When considering the viability of any options, commercial, technical and environmental factors should be explored.

Water:

Where possible, infrastructure should be located to minimise any effect on hydrology as far as possible. Surface mapping can inform the identification of areas that may be most at risk and allow a concentrated focus on prevention.

Potential sources of water resources for use during works should be identified at an early stage and abstraction from the source should result in the lowest environmental effect possible.

Design for surface water drainage should incorporate sustainable drainage techniques (SUDS) where possible which include surface storage and attenuation, and infiltration to ground if near surface hydrogeology is suitable. Assuming the site(s) is greenfield, run-off from rainfall should be limited to greenfield rates. In line with the requirements of Planning Policy Statement 25 and other equivalent bodies, SUDS should be used to attenuate any increases in surface run-off rates.

Measures to reduce the risk of pollution incidents and accidental discharges should include the use of impermeable membranes, bunded and tanked fuel storage, double lined settlement lagoons and oil/water interceptors.

Drilling specifications must ensure appropriate design of both drilling fluid and use of casing to prevent entry of drilling fluids to groundwater. Drilling specifications should allow for full solids removal from drill cuttings and ensuring that the reuse of drill muds is maximised (within the constraints imposed by hydrochemical sampling requirements). Regular monitoring of fluid flows and stored volumes should also form a component of the drilling specifications. Testing specifications must ensure that sufficient safe water storage is in place to allow for approximately 1 weeks' discharge to be stored on site prior to removal.

Implementation of water efficiency and re-use measures on site (such as demand management techniques, grey water recycling and rain water harvesting) should be implemented where appropriate, to minimise demand for water resources and any consequential environmental effect.

A Flood Risk Assessment (FRA) should be carried out which assesses all potential sources of flood risk and identifies any mitigation measures necessary. The FRA should include a surface drainage strategy, detailing how run-off from rainfall would be discharged at rates no higher than those from the pre existing conditions, and preferably at lower rates, up to the 50 year rainfall event, allowing for climate change.

All boreholes should be decommissioned in accordance with best practice guidance (i.e. EA and National Groundwater and Contaminated Land Centre guidance, Decommissioning Redundant Boreholes and Wells or equivalent).

Biodiversity:

At an early stage following site selection and prior to any works on site, a desk-based assessment followed by surveys (walkover surveys and detailed species specific surveys) as appropriate should be undertaken to determine the biodiversity value of the site(s). Extensive short-term site investigation surveys should avoid the breeding seasons.

Valuable biodiversity habitat or features should be retained where possible and any loss minimised as far as practically possible. Habitat fragmentation should be avoided by minimising the removal of habitat wildlife corridors. Careful consideration should be given to the routing of access roads to prevent/minimise habitat fragmentation.

Careful monitoring and control of drilling fluids should be exercised to prevent their entry into groundwater where they may seep into other aquatic environments.



Mitigation and enhancement measures

Design and Location (cont)

Any opportunities for habitat creation or enhancement, such as any opportunities to contribute towards or meet Local Biodiversity Action Plan targets, should be pursued (e.g. the use of visual screens, spoil heaps and sustainable drainage systems to create wildlife habitat). Any planting should comprise native species that provide habitat for affected ecosystems.

The reinstatement of the site should ensure that biodiversity habitat is restored to its previous condition and where possible enhanced into a more favourable condition. A management plan should be put in place where necessary to ensure proper growth and re-establishment.

Where an effect cannot be adequately mitigated then appropriate compensation measures would need to be developed.

Traffic and Transport:

Where practicable, consideration should be given to the use of more sustainable modes of transport such as by rail or sea. When considering the viability of any options, commercial, technical and environmental factors should be explored.

To minimise the movement of construction materials, locally sourced construction materials should be used where practicable and, where possible, any construction waste should be retained and used on site.

A road safety audit of the site access design should be undertaken prior to site investigation works commencing to ensure that the access is an appropriate design, capable of accommodating construction traffic, and would not compromise safety on the public highway.

Traffic should be routed to minimise the effect of vehicle movements to and from the site (particularly HGVs) on receptors. Deliveries of materials should be co-ordinated to prevent queuing of vehicles. Arrivals of materials should also be scheduled for outside peak hours to minimise any disruption to the existing highway network.

The provision of transport for personnel working at the site should be considered to minimise the reliance on private vehicle movements (e.g. through car sharing or the provision of buses).

Immediate areas external to the site should be subject to regular sweeping and washing to minimise dirt and dust on publicly accessible roads. Vehicles leaving the site should also pass through wheel washing installations prior to departure.

A regularly serviced modern lorry fleet should be used for the collection of waste, transportation of plant and other equipment and resources.

Contributions could be made towards improving the road network and public rights of way where appropriate.

Air Quality:

Measures to reduce the effects of increases in vehicular pollutant emissions and particulate matter should be implemented where possible. This could include: eco-driver training; ensuring all vehicle engines and plant on site are not left running; using low emission vehicles and plant fitted with catalysts, diesel particulate filters or similar devices; keeping plant well maintained and routinely serviced; requiring that all vehicles comply with exhaust emission regulations for their class; siting haul routes, and operating plant away from sensitive receptors (e.g. houses and schools); and maximising energy efficiency.

Where possible, the use of mains electricity to power equipment and plant would be preferential to diesel or petrol powered generators to minimise pollutant emissions to air.

The potential for renewable energy generation (e.g. solar panels, dedicated wind turbines, ground source heat pumps or biomass boilers) to meet energy needs on site could be considered. Plant should be maintained and routinely serviced to ensure it operates efficiently.

The use of screens and barriers to help reduce the effects of particulate matter should be considered, as should the orientation with respect to locally prevailing winds.

Any risk of causing nuisance dust arising from works should be reduced by making use of Best Available Techniques and selecting suitable energy efficient, low emission equipment.



Mitigation and enhancement measures

Design and Location (cont)

The following measures to suppress dust should be implemented: the use of wet sweeping and cleaning methods; use of vehicle wheel wash facilities; the enforcement of low speed limits along temporary roads; paving of haul routes on site even if temporary to prevent re-suspension of dust emissions; sheeting vehicles transporting loose or potentially dusty material; storage of dusty materials away from site boundaries; sealing or re-vegetating completed earthworks as soon as reasonably practicable; and the use of design/pre-fabrication to reduce the need for grinding, sawing and cutting.

Mixing of cement, grout and other similar materials should take place in enclosed areas remote from site boundaries and potential sensitive receptors. The delivery of fine powders or bulk cement should be delivered in enclosed tankers and stored in silos to prevent the emission of such materials.

Climate Change:

Where possible, construction materials with lower embodied energies should be utilised. When considering the detail of design and within engineering appraisal, the carbon associated with construction materials should be considered, for example it's source, distance to be transported, method of transport and volume. Where reasonable lower carbon alternatives are available they should be considered.

All buildings on site should be designed to the highest standards of energy efficiency incorporating features such as energy efficient insulation materials, and lighting and heating systems. This could include consideration of site orientation to optimise solar gain, insulation, passive ventilation techniques, use of photo-voltaics or other sources of renewable energy for on-site generation, and the potential for small scale Combined Heat and Power, as well as ensuring energy efficiency measures within all office equipment and fittings.

The consequences of climate change may be positively mitigated by avoiding situating buildings and infrastructure in a floodplain or other flood sensitive area and through the provision of appropriate drainage. All infrastructure key to the works, such as power supply and computer systems should be designed to be fully resilient to flooding such that in the event of localised flooding the works are not affected.

Noise and Vibration:

The appropriate amount of explosives to be used for seismic surveys and the detonation sequence should be calculated such that vibration levels are controlled to levels below the maximum permissible level.

The noisiest activities should be limited to daytime periods (including deliveries to site). Good practice measures that should be adopted may include the use of acoustic screening to help reduce off-site noise; selection of plant systems that generate minimum noise levels; enclosure of noisy plant and equipment within buildings or kiosks, if necessary fitted with acoustic panels; considered placement of equipment away from sensitive receptors; the use of padding between drilling pipes to reduce component movement; and use of 'quiet' (Smart) reversing alarms on vehicles.

Land Use:

The highest grade agricultural land should be avoided where possible and consultation should be undertaken with the landowners/tenant farmers as relevant in determining the location of drilling sites (particularly shallow boreholes) to minimise disruption to existing land uses.

The siting of the buildings and infrastructure should aim to minimise the need for additional access roads and the loss of noted landscape features or views.

Office accommodation could be located on previously developed land or make use of existing accommodation through reuse and refurbishment to minimise land take.

Land use requirements should be carefully considered to strike a balance between minimisation of land take (and therefore effects on existing land use) and incorporation of suitable measures required for mitigation or enhancement, notably landscape screening.



Mitigation and enhancement measures

Design and Location (cont)

Where effects on an existing land use are unavoidable through siting or design, particularly where the works could affect the viability of a business for the period of the works programme, compensation or benefits should be provided as appropriate, either financially or through the provision of similar land or alternative premises elsewhere.

Should any public rights of way be affected as a result of the works, they should be diverted to allow their continued use wherever possible.

Following completion of the site investigation works, the land should be restored to its previous condition and where possible a more favourable condition.

Socio-economics:

Any opportunities to employ local contractors and individuals for works or for the use of local materials and suppliers should be identified, although due consideration and adherence to local employment legislation is required (e.g. no discrimination on any grounds). Any potential to offer training opportunities (e.g. apprenticeship schemes) should be pursued.

Any increase in demand for services and accommodation arising from the works and its potential effect on the existing community should be considered carefully. Where possible, consideration should be given to opportunities for enhancement in the local area through the provision of improved or additional facilities or services, particularly where demand for such services would increase as a result of the works. Care should be taken to consider the effects and requirements of the community with respect to factors such as opportunities for access to services, facilities, leisure, recreation, education, training and housing.

Close consultation with the local community regarding potential improvements/enhancements is recommended to help ensure that local needs and wants are met.

Following completion of the surface-based site investigations, consideration should be given to letting or selling the office accommodation as serviced office space, which may benefit firms in the area. Alternatively, the accommodation could be gifted to the local community and converted for community space.

Health and Well-being:

Buildings, infrastructure and access roads should be sited as far as possible from site boundaries remote from potential sensitive receptors and any works that have the potential to have an effect on health and well-being (e.g. noisy and dust generating activities) should take place within enclosed area wherever possible.

Close consultation and full exchange of information with the local community, liaison with the local police and authorities, and the use of appropriate on-site security should minimise the risk of negative consequences of protest action, such as an increase in fear of crime.

The following hierarchal approach to addressing hazards should be followed where possible – eliminate hazards through design; where hazards cannot be designed out they should be isolated or protection to workers and the public should be provided; where the hazard cannot be avoided by protection or isolation, it's effects should be mitigated through design, process changes and management control measures.

Safety:

The design of the site(s) and activities should be reviewed by an independent examiner to ensure that hazards are appropriately addressed.

Site access should be restricted as appropriate and all personnel on site to be inducted/briefed, to wear appropriate Personal Protective Equipment and to be accompanied by another member of staff as necessary to help to reduce accidents. Third parties may be protected from any increase to the risk of health and safety through adequate protection around the construction site to prevent the public from entering the area.



Mitigation and enhancement measures

Design and Location (cont)

Waste:

Waste minimisation and management best practices should be implemented, with a focus on materials resource efficiency (using less and re-using more), in accordance with WRAP guidance, *Delivering Effective Waste Minimisation* and *Delivering Good Practice Waste Management*.

Materials usage and waste should be considered early in the design process and opportunities to 'design out waste' should be considered. This could involve: design with existing resources (taking account of resources available on site or close by); standardisation of building form, layout and materials; design for easy demolition, re-construction and adaptability; designing to material dimensions; use of made-to-measure materials; and the use of modern methods of construction (that eliminate or reduce the requirement for site cutting and handling of materials). This should involve early discussions between the client, designers, contractors and subcontractors to identify potential waste streams and their quantities. Guidance on waste minimisation through design is provided in the WRAP document, *Achieving Effective Waste Minimisation through Design: Guidance on designing out waste for construction clients, design teams and contractors*.

Where there is the potential for long-term use of buildings on the site(s) (e.g. offices), a high level of design quality and flexibility should be adopted to allow for future use.

Best practice procedures for the protection, storage and handling of materials should be followed. A robust logistics plan should be developed, identifying how materials are to be moved to, from and on site and how they are stored. This could include just in time delivery or the use of consolidation centres to help reduce damage to materials and products by minimising the amount of time stored on site, and take back schemes for surplus material.

The potential for materials wastage should be reduced through effective procurement; producing accurate estimates of materials required, ordering the correct amount of materials at the correct time, developing partnerships with suppliers who can implement waste minimisation at source; and setting up schemes with suppliers to take back surplus materials.

Provision should be made for the segregation of wastes to enable a high level of recycling. Options for re-use of materials on site should be identified. Where re-use and recycling is not possible, options for disposal should be investigated to minimise environmental effects.

Opportunities for the beneficial re-use of drilling cuttings should be explored (e.g. re-use of cuttings as a secondary aggregate). When considering the viability of any options, commercial, technical and environmental factors should be explored.

Resource Use:

All buildings on site should be designed to meet or exceed future Building Standards; this might require achievement of a BREEAM rating of 'very good' and with an aim to achieve 'excellent' where possible. All buildings should be designed to the highest standards of energy and water efficiency, incorporating features such as energy efficient insulation materials, lighting and heating systems and appliances (e.g. double glazing, energy efficient bulbs, 'A' rated white goods and dual low flush toilets) and systems for the collection and recycling of water (e.g. rain water and grey water recycling systems).

The potential for materials wastage should be reduced through effective procurement, providing accurate estimates of materials required, ordering the correct amount of materials at the correct time, and using supplies that take back surplus material.

The use of products and materials with good practice levels of recycled content and inherently lower embedded carbon (relative to other products meeting the same specification), or those with low environmental impact (e.g. those that are A-rated in the Green Guide specification) should be specified. AggRegain, the free sustainable aggregates information service provided by the WRAP Aggregates Programme (<http://www.aggregain.org.uk/>), provides a lot of useful information and advice on sourcing sustainable aggregates.



Mitigation and enhancement measures

Contractors

Contractors registered with the Considerate Constructors Scheme should be employed for works where possible, who commit to best practice construction methods.

All site investigations should be undertaken in accordance with BS 5930: 1999 (Code of Practice for Site Investigations), ISO 5667-11:2009, BS 6068-6.11:2009 (Guidance on sampling of groundwaters) and other relevant British Standards or equivalent as applicable.

Tender specifications should request a method statement providing information on how measures would be implemented to mitigate environmental effects.

An Environmental Management Plan should be developed and implemented, which ensures that all potentially significant environmental aspects of the activities are identified and understood, and provides clear measures for their management, including responsibilities and reporting. Contractors should also demonstrate suitable environmental certification (e.g. ISO 14001).

Good practice guidance in the protection of soil materials should be followed: Guidance on Good Practice for the Reclamation of Mineral Workings to Agriculture (DoE, 1996) and Good Practice for Handling Soils (MAFF, 2000).

The handling of any hazardous materials or fluids must be carried out in accordance with the relevant best practice guidance and make use of bunds and suitable storage tanks effectively through the provision of sealed areas with adequate storage and collection facilities.

A Spillage Response Plan should be developed and implemented, which sets out systems to ensure that pollution effects are contained and minimised and that clean-up procedures and spill kits are in place to respond effectively once an incident is discovered. Training should be provided to all staff working on the site on the spill response procedures and periodic auditing of the procedures should take place. Sufficient spill kits should be provided and maintained and the contents should be subject to periodic checks.

A Traffic Management Plan (TMP) should be prepared and adopted. The TMP is likely to include details on car parking, temporary road signage and traffic routing and timing. Similarly, a Green Travel Plan should also be developed and implemented for the office facilities, outlining measures to minimise private vehicle use such as the promotion of car sharing, the provision of services for workers to the site (i.e. buses) and the provision of public transport passes to encourage use where appropriate.

Routing strategies should be implemented for construction material transport in order to avoid, as far as possible, sensitive receptors and congestion effects. Deliveries should be co-ordinated by a logistics manager to prevent queuing of vehicles. Arrivals of materials should also be scheduled to outside of peak hours to minimise any disruption to the existing highway network.

The use of prescriptive guidelines for staff and contractor behaviour within nearby settlements should be considered in line with the opinions of local residents to minimise disruption and develop good working relationships through liaison.

A focus on implementing a safety culture should be adopted to reduce the risks to construction workers and local communities. Relevant legislation (e.g. the Borehole Sites and Operations Regulations 1999 (COMAH)) and best practice guidance should be adhered to and requirements exceeded where possible. Full implementation of Construction Design and Management (CDM) Regulations should apply to all works irrespective of scale or duration.

Where required, detailed method statements from contractors along with proof of permits to work, safe systems of working and sufficiently suitably qualified and experienced personnel should be obtained before issuing a contract.

A waste minimisation strategy should be implemented as part of the Site Waste Management Plan (SWMP) for the works. As a minimum, the SWMP should contain detailed measures to comply with relevant waste legislation but should also include good practice guidance and objectives in order to maximise the reduction, reuse and recovery of waste, with disposal to landfill as the least preferred option.

It is considered that the appointment of trained, experienced and professional contractors would also be beneficial to reducing construction waste generation as they may work more efficiently than those with less experience.



Mitigation and enhancement measures

Construction

Design and Location

The mitigation and enhancement measures recommended for the surface-based site investigations phase are also applicable to the construction phase. Additional measures specific to the construction phase are detailed below.

Landscape and Visual:

The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:

Within the constraints of the host rock, the footprint of surface facilities and infrastructure should be minimised as far as practically possible, and surface infrastructure and facilities appropriately sited to reduce any landscape and visual effect.

Consideration should be given to the receiving environment and sensitivity of receptors and the potential effects on key views and designated landscape areas. In addition, effects on local landscape features, elements, character and quality and locally designated and undesignated areas of landscape value, together with effects on local views, should be considered.

Temporary screens should be put in place prior to any construction works commencing, which can be replaced with surface bunds around the site as spoil from the excavation works becomes available.

Where possible, any landscape planting should be carried out at an early stage to allow the development of vegetation to help filter views of the surface works prior to commencement of construction work on site.

Any planting undertaken on or off-site should make use of locally native tree and shrub species. Dependent on its location, large belts or blocks of planting may not be characteristic of the landscape surrounding the site.

It may be appropriate to form several screening mounds at different distances from the security fence to reflect the landscape character of the site and surrounding area. The ends of these mounds should overlap to maintain a continuous screen around the site. The mound may also be developed in stages, targeting the views of construction works from key visual receptors first.

Cultural Heritage:

The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:

It is expected that a desk study and walkover would have been undertaken as part of the site investigation works, which could be revised and updated as necessary for the construction phase.

In addition to the assessment of effects on archaeological and built heritage features, the effect on historic landscapes should also be considered. This should include characterisation of the landscape and effects on any contribution that the heritage resource may make to tourism in the area.

Geology and Soils:

The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:

Opportunities for the beneficial re-use of excavated rock to be removed off-site should be explored. For example, excess excavated rock could be exported via a railhead for use as aggregate/construction material. The transport implications of exporting excavated rock off-site would need to be considered carefully. Where possible, the disposal of excavated rock to landfill should be avoided. The available options should be subject to assessment.



Mitigation and enhancement measures

Design and Location (cont)

Water:

The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:

The design for excavations should include grouting or lining of shafts and the drift tunnel as necessary to minimise ingress of water after construction. The timing and phasing of excavations should be planned to minimise the duration for which dewatering activities are required.

Adequate treatment of dewatering water (settlement to reduce turbidity) should be carried out prior to disposal. Where possible this water should be reinjected into the main water bearing formation from which it was pumped, to minimise any effects on water resources within this unit. A dewatering plan should be agreed with the EA or equivalent body prior to construction.

Where wastewater is not to be discharged to sewer it should be treated on site to acceptable standards before being discharged to local watercourses. On site treatment would include reedbeds and other sustainable treatment processes where appropriate, thereby adding biodiversity value to the site.

The potential pollution risk of excavated lower strength sedimentary rock should be mitigated by limiting exposure to air and water by establishing surface bunds quickly and in dry conditions, and by the rapid covering of excavated rock with spoil. Depending on the acid-generating potential, the excavated rock may also need to be sat on impermeable bases and run-off managed to reduce the potential for leachate.

The potential pollution risk of excavated evaporite rock should be mitigated by storage under cover.

Biodiversity:

The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:

As potential site locations are identified a Habitats Regulations Assessment (HRA) may be required to identify the potential effects on European protected habitats and species and propose specific mitigation measures to minimise any detrimental effects identified.

At an early stage following site selection, and prior to any works on site, a desk-based assessment followed by surveys (site walkover surveys followed by detailed species specific surveys in areas likely to be subject to direct disturbance) as appropriate should be undertaken to determine the biodiversity value of the sites (it is expected that a desk study and survey(s) would have been undertaken as part of the site investigation works, which could be revised and updated as necessary for the construction phase).

The design and layout should seek to retain or minimise loss of any valuable biodiversity habitat or features, whilst retaining linkages (i.e. wildlife corridors) between areas that have the potential to be isolated by development. Careful consideration should be given to the routing of access roads and rail infrastructure to prevent or minimise habitat fragmentation.

Traffic and Transport:

The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:

Where practicable, provision should be made for the transport of any plant, materials and wastes to and from the site via rail or sea. Other alternatives to road transport could be the use of conveyors (such as those used in quarrying and mining) as a means of transport to rail or port facilities. Consideration should be given to the potential longer-term use of any new infrastructure provided: whether a dedicated transport link for a GDF is provided or whether there are opportunities for wider industrial/commercial use of any new transport infrastructure. All available transport options should be subject to environmental assessment to determine their effect.



Mitigation and enhancement measures

Design and Location (cont)

Air Quality:

The mitigation and enhancement measures identified for the sites investigations phase should be continued as appropriate. Additional measures identified for this phase include:

Ventilation systems should be appropriately designed, in accordance with best practice, to minimise emissions of pollutants. Discharge stacks should be located more than 100m from any underground ventilation intake. Back-up systems and procedures should be in place to ensure that air quality is maintained in case of failure of the primary system or filtering.

Climate Change:

The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:

Development should not be considered within areas at risk of flooding from rivers or the sea unless the development can be protected to an appropriate degree. Drainage on site should be sufficient to manage surface water flows and minimise risk of site flood during heavy rainfall. All infrastructure key to the running of the facility, such as power supply and computer systems, should be designed to be fully resilient to flooding such that in the event of localised flooding the facility can remain fully safe and secure.

Noise and Vibration:

The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:

Acoustic screening may be incorporated in combination with landscape screening. Efficient plant should also be selected where possible that has low noise levels. Plant may also be enclosed within buildings if necessary. Chutes discharging rock may be lined with rubber to reduce noise effects.

Land Use:

The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:

The extent of land take required should be refined as the design of a GDF develops to allow more accurate assessment of the likely land use effects at the siting stage.

Socio-economics:

The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:

Ensure ongoing engagement with the affected community through the MRWS partnership (or equivalent) bodies to maintain the commitment to openness and transparency. Ensure the community benefits package is suitably implemented to provide lasting benefits (such as enhanced links to other employment opportunities), and ensure transferable skills are developed.

Developing dedicated facilities on-site, such as cement production, can help to mitigate the negative effects such as large scale use of a road network. Water borne transport of heavy materials such as aggregates mitigates against energy costs and promotes a low carbon solution.

As a result of its position on supply chains, a GDF is likely to be exposed to markets with average price increases above inflation and which experience substantial volatility. Stabilising these prices through financial hedging instruments and other mitigating strategy should be investigated as part of the development, to avoid socio-economic impacts.

Investment should be made in education and training to develop skills to be used throughout the project and ensure adequate skills are available towards the end of the operational phase, and the closure and post-closure phase.



Mitigation and enhancement measures	
Design and Location (cont)	<p>Health and Well-being:</p> <p><i>The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:</i></p> <p>Overall dust exposure should be controlled by minimising dust around the work area. Engineering controls (local exhaust ventilation) and containment methods (blast-cleaning machines and cabinets) should be installed to prevent dust from being released into the air. Workers should be provided with the appropriate Personal Protective Equipment (e.g. air supplied respirators under high dust conditions) where necessary to avoid breathing dusts and informed about the health effects of silica dust and good working practices that reduce dust. Vacuums with high-efficiency particulate air (HEPA) filter or wet-sweeping should be used.</p> <p>Maintain close communication of issues between contractors and the local community. This may be achieved through the use of relevant community forums.</p> <hr/> <p>Safety:</p> <p><i>The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:</i></p> <p>Ensure the safe storage of spoil and excavated rocks to exclude any safety risk.</p> <hr/> <p>Waste:</p> <p><i>The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. Additional measures identified for this phase include:</i></p> <p>Opportunities for the beneficial re-use of any surplus excavated rock should be explored. For example, excavated rock could be exported via railhead for use as aggregates/construction material.</p> <hr/> <p>Resource Use:</p> <p><i>The mitigation and enhancement measures identified for the surface-based site investigations phase should be continued as appropriate. No additional measures have been identified for this phase.</i></p>
Contractors	<p><i>The mitigation and enhancement measures identified for the previous phases remain relevant to the operational phase. No additional specific measures have been identified for contractors for this phase, although tender documents may wish contractors to specify how they will address specific issues at each phase.</i></p>
Operation	
Design and Location	<p>The mitigation and enhancement measures recommended for the previous phases are also applicable to the operation phase. Additional measures specific to the operation phase are detailed below.</p> <p>Landscape and Visual:</p> <p><i>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:</i></p> <p>Landscape mitigation and enhancements should be progressed and a maintenance plan put in place for the long-term management and upkeep of landscaped areas (taking account of water and biodiversity aspects).</p> <p>Excavated rock from surface bunds that is to be used for backfilling should be removed from the inside of the site to preserve the exterior visual integrity of the surface bunds, when viewed from locations outside the site.</p>



Mitigation and enhancement measures	
Design and Location (cont)	<p>Cultural Heritage:</p> <p>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</p>
	<p>Geology and Soils:</p> <p>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</p>
	<p>Water:</p> <p>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</p>
	<p>Biodiversity:</p> <p>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:</p> <p>Habitat creation or biodiversity enhancements should be progressed and a maintenance plan put in place for the long-term management of habitats.</p>
	<p>Traffic and Transport:</p> <p>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</p>
	<p>Air Quality:</p> <p>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</p>
	<p>Climate Change:</p> <p>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</p>
	<p>Noise and Vibration:</p> <p>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</p>
	<p>Land Use:</p> <p>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</p>
	<p>Socio-economics:</p> <p>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:</p> <p>Ensure the community benefits package is suitably implemented to provide lasting benefits (such as enhanced links to other employment opportunities), and ensure transferable skills are developed.</p>



Mitigation and enhancement measures	
Design and Location (cont)	Ensure ongoing engagement with the affected community through the MRWS partnership (or equivalent) bodies to maintain the commitment to openness and transparency.
	<p>Health and Well-being:</p> <p><i>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</i></p>
	<p>Safety:</p> <p><i>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</i></p>
	<p>Waste:</p> <p><i>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</i></p>
	<p>Resource Use, Utilities and Services:</p> <p><i>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</i></p>
Contractors	<i>The mitigation and enhancement measures identified for the previous phases remain relevant to the operational phase. No additional specific measures have been identified for contractors for this phase, although tender documents may wish contractors to specify how they will address specific issues at each phase.</i>
Closure and post-closure	
Design and Location	<p>The mitigation and enhancement measures recommended for the previous phases are also applicable to the closure and post-closure phase. Additional measures specific to the closure and post-closure phase are detailed below.</p> <p>Landscape and Visual:</p> <p><i>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:</i></p> <p>Given the timescale that would have passed since the construction of a GDF, the restoration of the site to its previous state may be inappropriate. Therefore, careful consideration should be given to the potential restoration at the time of closure, with input from local stakeholders.</p> <p>Where appropriate, any landscape features lost as a result of a GDF should be restored and habitat replanted like for like or to a better condition than previous, with maintenance carried out for a sufficient time to allow any habitat to establish.</p>
	<p>Cultural Heritage:</p> <p><i>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:</i></p> <p>Careful consideration should be given to the effect of any restoration works on cultural historic and archaeological assets and their settings at the time of closure. Any opportunities to restore or enhance cultural historic and archaeological assets and their settings as part of restoration works should be pursued.</p>



Mitigation and enhancement measures

Design and Location (cont)

Given the timescale that would have passed since the construction of a GDF, surface facilities and infrastructure may have become part of our cultural heritage. Therefore, careful consideration should be given to their cultural heritage value and appropriate protection afforded where necessary.

Geology and Soils:

The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:

For high quality reclamation the dump truck and back acter method is recommended (soils to be lifted by back acter in separate layers and transported by dump truck), as this is considered to minimise damage to soil materials during soil handling operations.

Soils should be restored onto a stable but permeable substrate. For the reclamation of high quality land, slopes should not exceed 1 in 8. Minimum recommended slopes for restored agricultural land are 1:100. Following restoration of a GDF site to its pre-construction condition, a suitable aftercare regime should be put in place.

Opportunities for the beneficial re-use of excavated rock retained on site within the surface bunds should be explored. For example, excess excavated rock could be exported via railhead for use as aggregates/construction materials. The transport implications of exporting excavated rock off-site would need to be considered carefully. Where possible, the disposal of excavated rock to landfill should be avoided. The available options should be subject to environmental assessment.

Water:

The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:

All boreholes no longer required for ongoing monitoring should to be decommissioned in accordance with best practice guidance (i.e. EA and National Groundwater and Contaminated Land Centre guidance, Decommissioning Redundant Boreholes and Wells or equivalent). The correct sealing of boreholes within overlying strata is important to prevent rapid migration pathways.

Site restoration should ensure a similar surface run-off regime to that originally present.

Biodiversity:

The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:

Prior to site restoration, it is recommended that surveys are undertaken (walkover surveys and detailed species specific surveys) as appropriate to determine the biodiversity value of the sites. Valuable biodiversity habitat or features should be retained and where possible enhanced into a more favourable condition.

Any opportunities for habitat improvement and enhancement (e.g. any opportunities to contribute towards or meet Local Biodiversity Action Plan targets) should be pursued in consultation with Natural England, the local Wildlife Trust and other appropriate bodies.

The reinstatement of the site should ensure that habitat is restored to its previous condition and, where possible, enhanced into a more favourable condition. A management plan should be put in place where necessary to ensure the long-term success of any biodiversity mitigation and enhancements.



Mitigation and enhancement measures

Design and Location (cont)

Traffic and Transport:

The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:

Prior to decommissioning, consideration should be given to the potential longer-term use of any transport infrastructure provided. Any opportunities for wider industrial/commercial use of any transport infrastructure following post-closure should be explored.

Any access routes in place prior to construction should be restored to pre-construction condition and enhanced wherever possible.

Air Quality:

The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.

Climate Change:

The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.

Noise and Vibration:

The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.

Land Use:

The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:

Given the timescale that would have passed since the construction of a GDF, the restoration of the site to its previous state may be inappropriate. Therefore, careful consideration should be given to the potential restoration at the time of closure, with input from local stakeholders.

Socio-economics:

The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:

The community benefits package agreed at the beginning of the project is likely to continue to provide socio-economic benefits beyond the closure of the facility for future generations (such as improved transport links which may help improve access to employment opportunities elsewhere).

There is a commitment by the NDA to provide long-term transferable skills programmes which are likely to reduce the effects of the facility's closure by ensuring adequate training so that relevant skills can be transferred to other industries or projects. In particular, there may be a need for future radioactive waste disposal following future nuclear programmes.

Health and well-being:

The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.



Mitigation and enhancement measures	
Design and Location (cont)	<p>Safety:</p> <p><i>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. No additional specific measures were identified at this stage.</i></p>
	<p>Waste:</p> <p><i>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:</i></p> <p>A demolition strategy should be developed to consider the options for re-use or recycling of materials wherever possible, making the most of the opportunities available at that time. This could include supply of 'waste' materials from a GDF site to other construction sites elsewhere.</p>
	<p>Resource Use, Utilities and Services:</p> <p><i>The mitigation and enhancement measures identified for the previous phases should be continued as appropriate. Additional measures identified for this phase include:</i></p> <p>Opportunities for the beneficial re-use of any surplus excavated rock remaining on site should be explored. For example, excavated rock could be exported via railhead for use as aggregates/construction material.</p>
Contractors	<p><i>The mitigation and enhancement measures identified for the previous phases remain relevant to the closure and post-closure phase. No additional specific measures have been identified for contractors for this phase, although tender documents may wish contractors to specify how they will address specific issues at each phase.</i></p>



5. Conclusions

This Generic Environmental and Sustainability Report presents an assessment of the potential environmental and wider sustainability effects of illustrative geological disposal concepts for three different host rock types (higher strength rock, lower strength sedimentary rock and evaporite rock), as assessed against 16 sustainability themes and objectives. It has been undertaken to inform the continuing development of a range of disposal facility concepts for HAW and to provide information to communities that have expressed an interest (or are considering expressing an interest) in participating in the site selection process and in hosting a disposal facility.

5.1 What would be the significant effects?

The assessment has identified several potentially significant positive and negative effects that would be associated with one or more phases of GDF implementation (irrespective of host rock type or waste inventory considered). These are:

- **Potentially significant positive effects:**
 - Compliance with UK Government policy on managing HAW in the long-term through geological disposal.
 - Socio-economic effects associated with the investment and employment created during construction, operation and closure of a GDF.
- **Potentially significant negative effects:**
 - During construction and operation, potentially significant negative effects associated with geology and soils, transport and traffic, climate change, waste and resource use.

The differences between potential effects associated with the different illustrative geological disposal concepts are largely affected by two factors. Firstly, the volume of rock that would have to be excavated, which would be dependant on the volume of waste to be emplaced and, secondly, the host rock type, which would dictate the design of underground facilities and construction material requirements. Together, these dictate how the excavated rock could be used and managed, with consequent effects on traffic and transport movements that in turn would give rise to a number of related effects (e.g. on local air quality, climate change, waste arisings and resource use).

5.1.1 What would be the effects of different waste inventories?

It has been assumed that the scale of surface development for a GDF and the maximum rate of waste package delivery would be the same for the different waste inventories. Consequently, in the case of the Derived Inventory Upper Inventory (which consists of greater volumes of waste) radioactive waste would be delivered over a longer period. In terms of the surface facilities there would not, therefore, be any significant differences in potential effects



on landscape character and visual amenity, cultural heritage and archaeology, soils, surface water quality and flood risk, biodiversity and land use (environmental aspects that would be affected by the scale of surface development) between the different waste inventories. Some effects might be evident over a longer time period in the case of the Derived Inventory Upper Inventory, but given the overall scale of operations and the time periods involved, such differences would probably not be significant.

However, in order to accommodate different volumes of radioactive wastes, the footprint of the underground facility would vary for the different waste inventories. Due to the increased size of the underground facility, and the associated increase in timescales with the emplacement of greater volumes of radioactive wastes, the potential effect of constructing a GDF to dispose of the Derived Inventory Upper Inventory radioactive waste volumes on geology, groundwater, traffic and transport, air quality, climate change, waste and resource use, utilities and services could be greater than that of the Derived Inventory Reference Case excluding Pu/U. This would be due to the increase in the volume of host rock affected, with the potential for greater effects on geology and groundwater flows; an increase in materials required to be imported to the site (with an associated increase in embodied carbon); and an increase in waste generated, particularly surplus excavated rock to be removed off-site, with greater transport, air quality and climate change effects.

5.1.2 What would be the effects of different host rock types?

Although the scope of the surface-based site investigations would be broadly similar for each of the three host rock types, there may be differences in the implementation of surface-based site investigations, as follows:

- For the higher strength rock type, if the host rock extends to surface it may be appropriate to use relatively small mobile drilling rigs as such boreholes can be drilled at a relatively small diameter with less steel casing required. Compared with the larger drilling rigs which would be required for all other host rock types, such small rigs require fewer drilling crew, a smaller footprint, less supporting infrastructure and can be operated during daylight hours (compared with 24/7 working for larger drilling rigs). As such there is the potential for reduced environmental impacts when using such equipment.
- Site investigations for lower strength sedimentary rock, by nature of their relatively homogeneous (uniform) structure and composition, may require fewer deep boreholes to be constructed (in comparison to site investigations for higher strength rock), with a greater reliance on geophysical surveys. As such there is the potential for reduced local impacts by nature of the reduced number of borehole locations.

Similarly, it is assumed that the surface facilities and infrastructure would be of a similar scale for the different host rock types. However, the underground facility footprint would vary, with the lower strength sedimentary rock type having the largest underground footprint, and the higher strength rock type having the smallest.

Due to the increased size of underground facility footprint, there would be the potential for a GDF within lower strength sedimentary rock to have a greater effect on groundwater. In addition, the potential effect of the lower strength sedimentary rock type on surface water quality could be greater, as this rock type may contain sufficient



sulphide to cause acid generating reactions on exposure to air and water, giving rise to the potential for contamination of water when stored in surface bunds. Similarly, the evaporite rock type halite is highly soluble in fresh water and therefore if excavated halite rock were to come in contact with water whilst stored within the surface facilities the potential would exist for contamination of surface water courses with high chloride waters. The evaporite rock anhydrite, however, is less soluble, and therefore the pollution risk would be less than halite. Notwithstanding this, the evaporite rock would be stored within a suitably designed area and therefore adverse effects would be unlikely.

Given the footprint of the underground facility and the volume of rock excavated, there would be the potential for the construction of a GDF to affect sites of recognised importance for their geological value (e.g. SSSI or RIGS), although the designation is typically determined by the surface geology rather than the deeper stratigraphy. Such effects would be site specific and therefore is uncertain at this stage. However, taking account of scale there is the potential for the lower strength sedimentary rock type to have a greater impact when compared to the other host rock types due to the increased size in underground facility footprint.

Similarly, in the case of the higher strength rock and evaporite rock types, the construction of a GDF could also result in the sterilisation of mineral resources/reserves (rendering them incapable of being extracted), with the potential for the evaporite rock type to have the greatest effect due to the increased size of the underground facility footprint. Any effects on minerals resources/reserves would be permanent. The construction of a GDF within lower strength sedimentary rock would be unlikely to have a direct effect on mineral resources/reserves due to its low commercial value.

The quantity of host rock excavated from the construction of underground facilities would vary for the different host rock types, with the higher strength rock type resulting in the excavation of the greatest quantity of host rock, and the evaporite rock type the least. However, the illustrative geological disposal concept for the evaporite rock type would potentially generate the greatest quantities of surplus excavated rock to be removed off-site when compared to the other host rock types, due to the differences in excavated rock usage on site. In the case of the higher strength and lower strength sedimentary rock types, a significant volume of the excavated rock would be stored on site in surface bunds, and a proportion used for backfilling. In the case of the evaporite rock type, none of the excavated rock would be used for surface bunding or landscaping as it is not suitable for this use. Any surface bunds required to screen the site would therefore need to be constructed using spoil from the construction works (e.g. from top-soil stripping), or material may need to be imported for this purpose. Excavated evaporite rock that would be required for backfilling during the operational and closure phases would require a dedicated storage area on site.

Due to the storage of greater quantities of excavated rock on site, the higher and lower strength sedimentary rock types could have a greater effect on landscape character and visual amenity, cultural heritage and archaeology, soils, surface water quality and flood risk, biodiversity and land use (environmental aspects that would be affected by the scale of surface development). Given that a smaller volume of excavated rock would be stored on site in the case of the evaporite rock type when compared to the other host rock types, surface disturbance could be less. Notwithstanding this, as a greater quantity of surplus excavated rock would need to be taken off-site, carbon



dioxide emissions associated with the transport of surplus rock off-site could be greater for the evaporite rock type when compared to the other host rock types.

The surplus excavated rock generated from the construction of an underground facility would result in a significant waste stream. Although the construction of a GDF within lower strength sedimentary rock would not result in the largest quantities of surplus excavated rock to be removed off-site, it could have the greatest effect in relation to waste arisings, as opportunities for the beneficial re-use of any surplus excavated rock could be limited by its low commercial value. Higher strength rock and evaporite rock in comparison are of commercial value, particularly the evaporite rock halite, which is used widely for de-icing roads, for chlorine production, for food seasoning and for medicinal purposes.

For all of the host rock types, surplus excavated rock is assumed to be transported off-site via rail and therefore no significant effects on the road network are anticipated. For the higher strength rock Derived Inventory Reference Case excluding Pu/U, no excavated rock would need to be transported off-site.

The import of construction and buffer/backfill materials to the site, which is assumed to be transported by road, could potentially have the greatest effect on the road network. In the case of the higher strength rock and evaporite rock types, the excavated rock from the construction of the underground facilities would meet requirements for backfilling of the waste disposal areas during the operational phase, negating the need to import any crushed rock for this purpose. The lower strength sedimentary rock, however, would not be suitable for backfilling, and therefore all backfill material would need to be imported to the site.

During the construction and operational phase, although a significant proportion of excavated rock would be retained on site for the higher strength rock type, there would be a requirement for greater quantities of both construction materials and buffer/backfill material for the higher strength rock type when compared to the other host rock types, with the evaporite rock type requiring the least. Consequently, a GDF within higher strength rock may give rise to more significant effects on traffic and air quality during the construction and operational phase. Similarly, with respect to resource use and embodied carbon, construction of a GDF within higher strength rock may have a more significant effect when compared to the other host rock types.

Overall, however, for the construction and operation phase¹⁸, for the Derived Inventory Reference Case the evaporite rock type would probably generate the greatest amount of transport related CO₂ emissions, as although fewer construction and buffer/backfill materials would be required when compared to the other host rock types, a significantly greater volume of surplus excavated rock would need to be removed off-site.

¹⁸ Total transport related CO₂ emissions for the construction and operation phase takes account of the CO₂ emissions estimates for the transport of surplus excavated rock off-site, for the transport of ILW/LLW vault, HLW/SF disposal tunnel, underground accesses (drift and/or shafts) and common service area construction materials, and ILW/LLW vault and HLW/SF buffer/backfill material.



For the Derived Inventory Upper Inventory the lower strength sedimentary rock type would probably generate the greatest amount of transport related CO₂ emissions, due to the volume of surplus excavated rock to be removed off-site and the volume of construction materials and buffer/backfill materials to be transported to the site.

During the closure and post-closure phase, the lower strength sedimentary rock type could give rise to more significant effects, due to the need to import all mass backfill material. For both the higher strength rock and evaporite rock types, excavated rock stored on site could meet crushed rock drift and/or shafts and common services area backfill requirements, negating the need to import crushed rock for backfilling of these areas. In the case of lower strength sedimentary rock, all mass backfill material would need to be imported to the site, resulting in a significant number of transport movements, with associated effects on air quality and climate change, and resource use and markets/supply chains.

In the case of the higher strength rock and evaporite rock types, it is unknown whether crushed rock backfill requirements for backfilling the underground roadways and facilities could be met using excavated rock from the construction of the underground facility. There would be surplus excavated rock (currently assumed to be transported off-site) which could possibly be used for this purpose if this surplus was retained on site.

It is noted in the case of the higher strength and lower strength sedimentary rock types that bentonite, required for buffer/backfilling, is not widely available in the UK and therefore may need to be shipped from abroad. In addition, the import of bentonite could also have an effect on minerals resources/reserves elsewhere, with the potential for a GDF within lower strength sedimentary rock to have the greatest effect due to the requirement for greater quantities of bentonite over the duration of the project.

Following decommissioning and site restoration, the scale of any residual effects at surface could differ between the different host rock types. Assuming that the dedicated storage area for excavated rock would be demolished as part of decommissioning for the evaporite rock type, any potential residual effects on landscape character and visual amenity, and on land uses could be less for the evaporite rock type as only the smaller surface screening bunds would remain on site.

For all host rock types, a GDF would fulfil a number of policy and legislative commitments for the long-term management of radioactive wastes in accordance with the MRWS Programme. However, the construction and operation of a GDF could be associated with a significant carbon footprint, which if not matched by corresponding reductions elsewhere in the UK economy could detract from the UK meeting its obligations under the Climate Change Act 2008.

Employment opportunities would be generated, particularly during construction and operation, a proportion of which may be available to local people, and could benefit the local economy (e.g. through the increased use of garages, shops and accommodation). There may be detrimental effects on local communities, due to disturbance from construction and operational activities generating nuisance dust and noise.

The community benefits package would result in investment in the area around a GDF to support the enhancement of opportunities for the local population, help address locally identified needs and issues, and provide benefits to



enable subsequent generations to benefit throughout the lifespan of a GDF and beyond post-closure. The community benefits package would probably not be affected significantly by the host rock type, but may help to ensure that when there are employment spikes at the facility (during construction and operational activities) there are opportunities for subsequent generations of the local community to take advantage of such opportunities through training and skills development.

5.1.3 What would be the effects of different transport scenarios?

There would probably not be any difference in potential effects associated with the transport of radioactive waste between the different host rock types, as all would be designed to accept the same volumes of radioactive wastes. However, the carbon emissions associated with the transport of radioactive waste by rail (the Road/Rail scenario, which assumes a 70:30 rail and road split) are estimated to be greater than if radioactive waste is transported predominantly by sea (the Sea/Road/Rail scenario, which assumes a 80:10:10 sea, rail and road split).

5.1.4 What would be the effects during the different implementation phases?

The effects associated with a site investigation phase would probably be an order of magnitude less than the effects for the other phases. This would be due to the relatively small scale of the works and the fact that they would be spread over a number of years, with significant effects at any one borehole site being apparent for only a few months.

The magnitude of effects would be at its greatest during the construction and operation phases, with employment effects expected to be greatest during construction.

By the closure and post-closure stage, given the timescales involved and that a site location is not known at this stage, many of the potential effects have been identified as uncertain, although the potential for both adverse and beneficial effects has been noted. At closure and post-closure, it is anticipated that, in general terms, the magnitude and significance of effects, where identified, would decrease in most cases when compared to the construction and operation phases.

5.1.5 What are the effects of uncertainty on the assessment?

At this stage there are uncertainties about the location, siting and design of a GDF. This has particularly affected the assessment of significance for those effects where locational factors are key, namely:

- Cultural heritage and archaeological value.
- Water resources, floodplains and flood sensitive areas.
- Biodiversity.



- Air quality.
- The location of the site in relation to strategic and local road networks, and sensitive receptors such as houses and schools.
- Land use.
- The socio-economic composition of the receiving community where a GDF could be located.

In consequence, whilst the assessment has been able to identify and characterise the potential effects associated with the above, it has not been able to conclude whether such effects would be neutral, adverse or significantly adverse. At Stage 4 of the MRWS site selection process many of these uncertain effects would be resolved following further study and more detailed assessment. As these uncertainties become clearer, further assessment would identify more potentially negative effects than are reflected in this report. However, with clarity on candidate sites would come the opportunity to review potentially negative effects, resolve the use of mitigating measures and identify opportunities for enhancement.

5.2 Next steps

This report identifies, characterises and assesses the likely non-radiological environmental, social and economic effects that may arise at a generic (i.e. non-site-specific) level from implementing different illustrative geological disposal concepts in different geological settings (host rock types). The report also outlines potential measures that could be used to mitigate adverse, or enhance beneficial effects, that have been identified. These measures could be incorporated into future design iterations for geological disposal concepts, or taken into consideration during future stages of the process for site selection.

The report provides information for communities that have expressed an interest (or are considering expressing an interest) in participating in the site selection process and in hosting a GDF.

At the end of Stage 3 of the MRWS site selection process, those communities that have taken a decision to participate in the next stage and have not been screened out for obvious geological reasons would progress to Stage 4. The UK Government would then ask the NDA to undertake further investigations in these communities to evaluate their potential suitability for hosting a GDF and to assess the potential effects of building and operating a disposal facility in the area.

A formal SEA of the NDA's proposals for how a GDF would be implemented in each candidate community, including the proposals for surface-based investigations, would then be undertaken. The NDA would lead and consult on an inclusive SEA process that would consider:

- The proposed scope of the SEA (including, for example, the level of detail of the assessment, the potential effects to be considered, geological disposal concepts and options to be assessed, and the proposed form and content of the Environmental and Sustainability Report); and



- The subsequent findings of the assessment.

The approach and findings of the generic assessment presented in this report would be considered during both scoping and assessment for the Stage 4 SEA. For example, as more detailed regional and site-specific information became available the generic effects identified in this assessment for Stage 3 may be quantified or more specifically identified. **Table 5.1** sets out the additional information that would be needed during Stage 4 to address some of the uncertainties identified in this report and to provide more detail/certainty on assessed effects.

Table 5.1 Summary of information requirements

Sustainability theme	Information requirement
Policies and Planning	<p>Relevant regional and local planning policies would need to be identified once the site(s) location becomes known.</p> <p>The effects of the closure and post-closure phase in relation to policies and planning would need to be reviewed at a later stage prior to the commencement of any closure and post-closure activities.</p>
Landscape and Visual	<p>Site-specific information and more detailed information on the scheme design is required to establish the scale of any effects on landscape character and visual amenity. Following site selection, information on the receiving environment and sensitivity of receptors would need to be gathered through a desk top study and site visit in order to determine the landscape character and quality of the site(s) and surrounds.</p> <p>The landscape and visual effects of the closure and post-closure phase would need to be reviewed at a later stage prior to the commencement of any closure and post-closure activities. Given the period of time that would have lapsed substantial changes in landscape character may have taken place. Information on the current landscape character and quality of the site and its surrounds would therefore be required. This would inform the identification of a suitable restoration programme.</p>
Cultural Heritage	<p>Site-specific information and more detailed information on the scheme design is required to establish the likelihood and scale of any effects on cultural heritage and archaeology. Following site selection, the cultural heritage and archaeological value of the site(s) and surrounds would need to be determined through a desk top study and site visits as appropriate.</p> <p>The effects of the closure and post-closure phase on cultural heritage would need to be reviewed at a later stage prior to the commencement of any closure and post-closure activities. Given the period of time that would have lapsed there is the potential for the surface facilities and infrastructure to have become part of the cultural heritage. The cultural heritage value of the surface facilities would therefore need to be determined.</p>
Geology and Soils	<p>Site-specific information and more detailed information on the scheme design is required to determine the potential for land contamination and to establish the likelihood of any effects on soils, designated geological sites and mineral resources/reserves.</p>
Water	<p>Site-specific information and more detailed information on the scheme design is required to determine the potential effects on water resources and flood risk, particularly groundwater. Regulatory discharge and abstraction permitting would be site-specific.</p>
Biodiversity, Flora and Fauna	<p>Site-specific information and more detailed information on the scheme design is required to establish the likelihood of any effects on biodiversity. Information is required on the type, features and conservation characteristics of habitats in the area, especially any designated areas (e.g. SSSI, Special Area of Conservation, Ramsar etc).</p> <p>The effects of the closure and post-closure phase on biodiversity would need to be reviewed at a later stage prior to the commencement of any closure and post-closure activities. Given the period of time that would have lapsed there is the potential for landscape features and undeveloped areas within the site to have become of biodiversity value, which would therefore need to be determined.</p>
Traffic and Transport	<p>Site-specific information and more detailed information on the scheme design is required to establish the likelihood of any effects on traffic, such as the proposed transport method and site access, materials and resource requirements and sources, the capacity and sensitivity of the existing road network, and traffic routing.</p>



Sustainability theme	Information requirement
Air Quality	Site-specific information and more detailed information on the scheme design is required to establish the likelihood of any effects on local air quality. Following site selection, the existing local air quality needs to be established and any sensitive receptors identified (e.g. such as schools, homes and healthcare facilities). Further information on the levels of specific pollutants emitted from activities and the effect that these may have on baseline air quality (e.g. Air Quality Management Areas) is also required.
Climate Change	Site-specific information and more detailed information on the scheme design is required to establish the likelihood of any climate change effects.
Noise and Vibration	Site-specific information and more detailed information on the scheme design is required to establish the extent of any noise and vibration effects, including the location of the site in relation to sensitive receptors (e.g. residents), the topography and landscaping of the site (which can affect noise and vibration propagation), information on working hours, the likely areas of working, and the noise levels of equipment to be used.
Land Use	Site-specific information and more detailed information on the scheme design is required to determine the likelihood of effects on land uses. The effects of the closure and post-closure phase on land uses would need to be reviewed at a later stage prior to the commencement of any closure and post-closure activities. Given the period of time that would have lapsed substantial changes in surrounding land use may have taken place. Existing land use patterns would therefore need to be considered to inform the identification of a suitable restoration programme.
Socio-economics	Site-specific information is required to establish the extent of any effects, particularly the location of the site in relation to local communities, markets and sensitive receptors (e.g. residents). Further information on the proposed scheme design and construction methods is also required to enable a more detailed and accurate assessment of the effects on supply chains and markets to be made.
Health and well-being	Site-specific information and more detailed information on the scheme design is required to determine the likelihood of effects on health and well-being. Further information is required on the proximity of the site(s) to sensitive receptors to identify the likely effects in more detail.
Safety	Site-specific information and more detailed information on the scheme design is required to determine safety effects. Further information is required on the proximity of the site(s) to sensitive receptors, and the proposed scheme design and methods, to identify the likely effects in more detail. In particular, the exposure of sensitive receptors to hazards associated with normal activities as well as accident and emergency situations should be considered.
Waste	More detailed information on the proposed scheme design, construction, buffer and backfill methods and options for the end use of excavated rock is required to enable a more detailed and accurate assessment of waste arisings to be made. Information on potential uses, markets and demand for waste excavated rock is required to inform the identification of potential options for the re-use of waste excavated rock. Similarly, information on the availability and capacity of waste management facilities in the vicinity of the site would be useful in identifying the best method of managing waste, whilst minimising transportation through the utilisation of local facilities where possible.
Resource Use, Utilities and Services	Further information on the proposed scheme design, construction methods and options for the end use of excavated rock is required to enable a more detailed and accurate assessment of resource use to be made. Information on potential resource markets and demand is required to inform the assessment of effects. Site-specific information is required to determine the existing availability of utilities and services and thus the potential effect on utilities and services provision.



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Appendix A Illustrative geological disposal concepts

Figure A1 Illustration of the UK Intermediate Level Waste/Low Level Waste Concept (Nuclear Decommissioning Authority, UK)

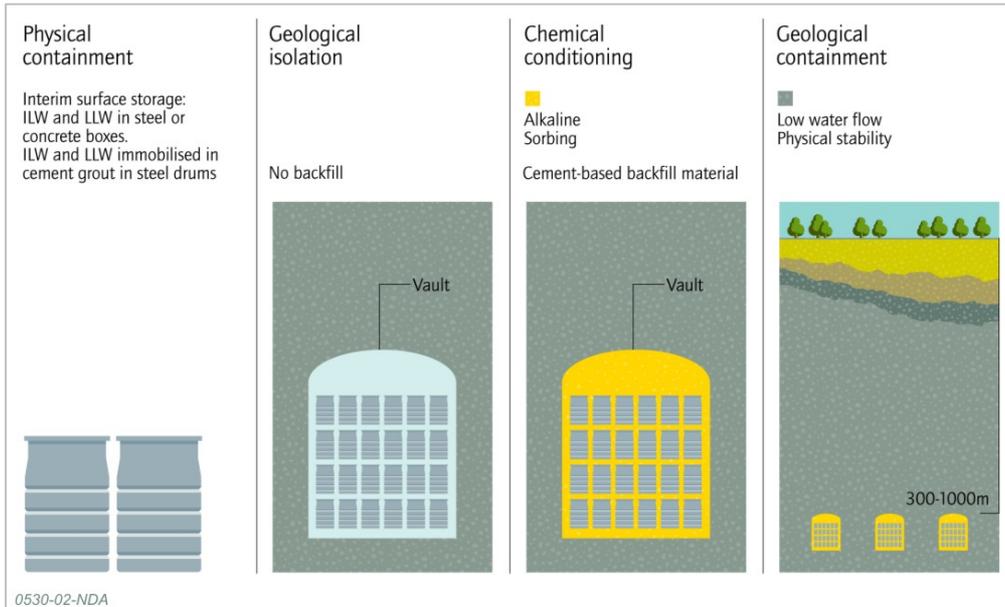
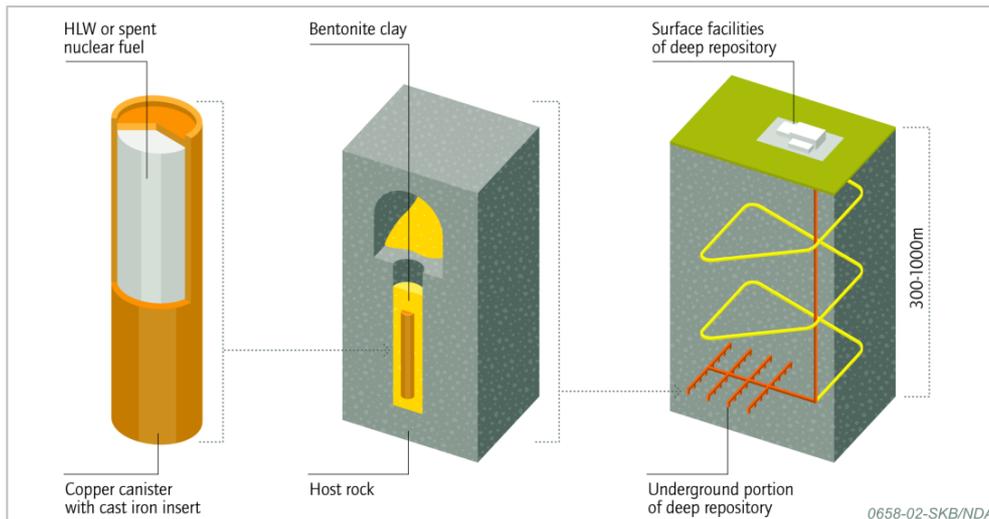


Figure A2 Illustration of the KBS-3V Concept (SKB, Sweden – as adapted by the Nuclear Decommissioning Authority, 2010)



Source: Nuclear Decommissioning Authority (NDA) (2010)



Figure A3 Illustration of the Opalinus Clay Concept (Nagra, Switzerland)

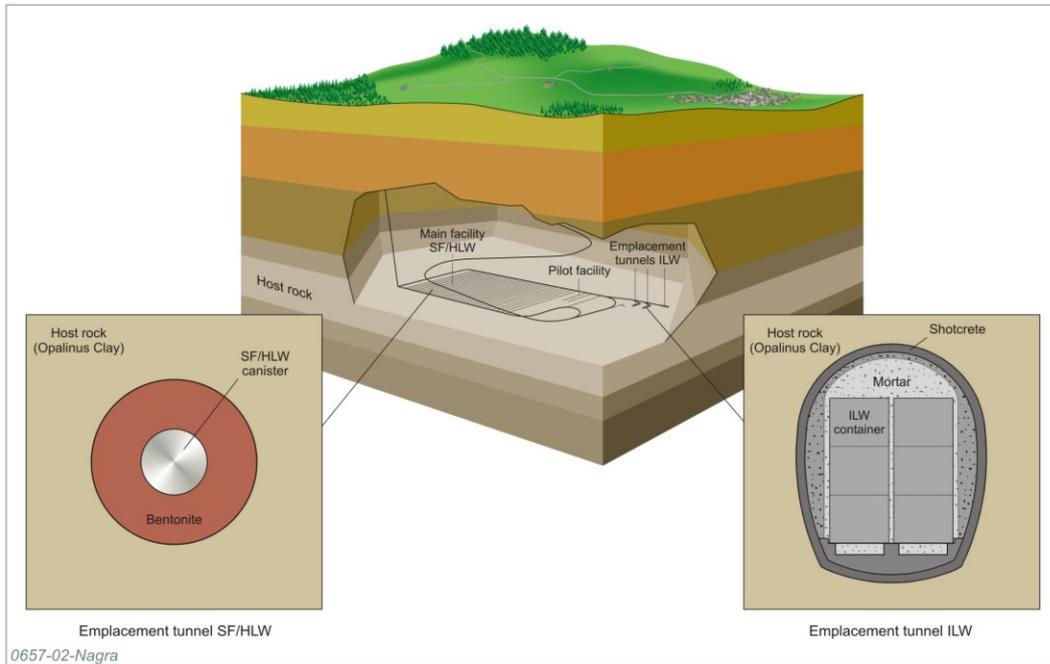


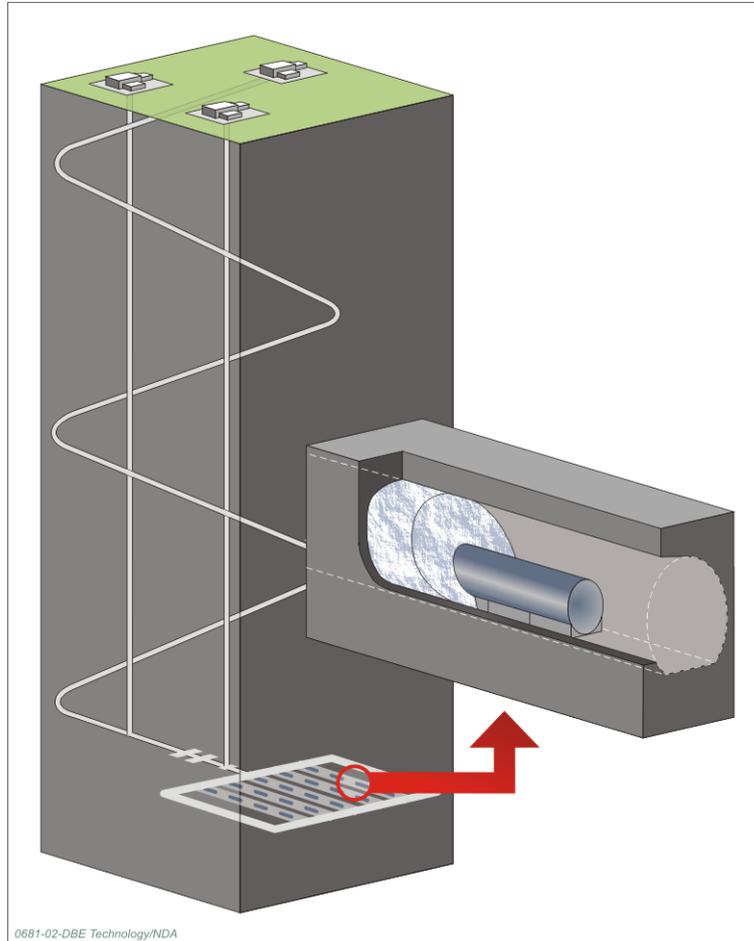
Figure A4 Illustration of the Waste Isolation Pilot Plant Bedded Salt Concept (US-DOE, USA)



Source: NDA (2010)



Figure A5 Illustration of the Salt Dome Concept (DBE-Technology, Germany – as adapted by the Nuclear Decommissioning Authority)



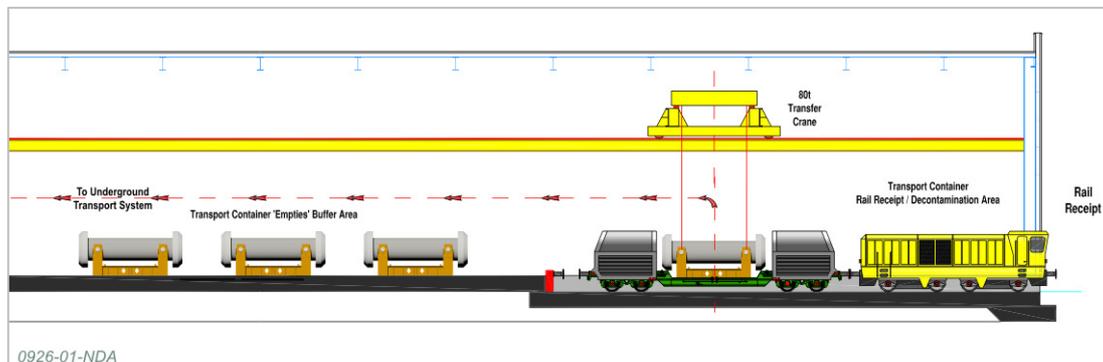
Source: NDA (2010)



Figure A6 Illustration of a Geological Disposal Facility surface receipt and transfer facility for Intermediate Level Waste/Low Level Waste (Nuclear Decommissioning Authority, UK)



Figure A7 Illustration of a Geological Disposal Facility surface receipt and transfer facility for High Level Waste/Spent Fuel (Nuclear Decommissioning Authority, UK)



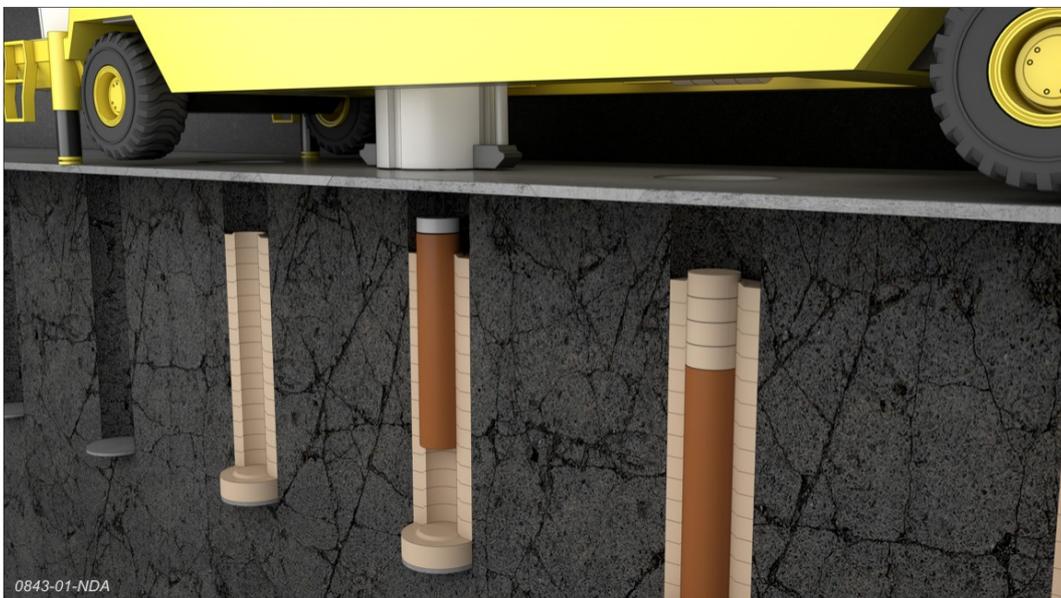
Source: NDA (2010)



Figure A8 Illustration of a Geological Disposal Facility unshielded Intermediate Level Waste vault in higher strength rock (Nuclear Decommissioning Authority, UK)



FigureA9 Illustration of a Geological Disposal Facility High Level Waste disposal tunnel in higher strength rock (Nuclear Decommissioning Authority, UK)



Source: NDA (2010)



Figure A10 Illustration of a Geological Disposal Facility unshielded Intermediate Level Waste vault in lower strength sedimentary rock (Nuclear Decommissioning Authority, UK)

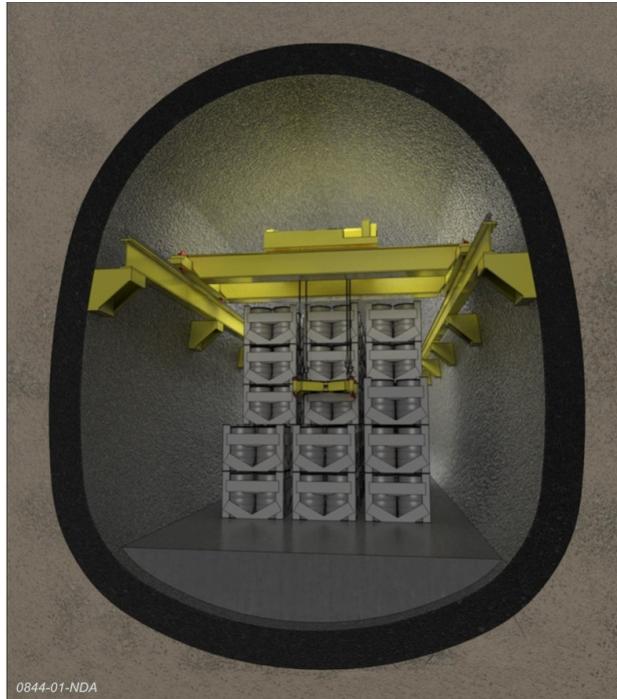


Figure A11 Illustration of a Geological Disposal Facility High Level Waste disposal tunnel in lower strength sedimentary rock (Nuclear Decommissioning Authority, UK)



Source: NDA (2010)



Figure A12 Illustration of a Geological Disposal Facility unshielded Intermediate Level Waste vault in evaporite rock (Nuclear Decommissioning Authority, UK)



Figure A13 Illustration of a Geological Disposal Facility High Level Waste disposal tunnel in evaporite rock (Nuclear Decommissioning Authority, UK)



Source: NDA (2010)



Appendix B Plans and programmes

This appendix presents the outcomes of the review of international, European, national and regional plans, programmes, strategies and policies considered relevant to geological disposal. The findings of the review informed the development of the assessment framework by ensuring that the issues covered by the plans and programmes were adequately covered within the sustainability objectives and supporting guide questions (refer to **Section 3.2** for more information).

Table B1 Plans and programmes review

Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
International		
<i>International Atomic Energy Agency (IAEA) (1994) Convention on Nuclear Safety</i>	<p>Adopted in Vienna in 1994, the convention aims to legally commit participating States operating land based nuclear power stations to maintain a high level of safety by setting international benchmarks.</p> <p>The convention is an incentive instrument designed to achieve higher levels of safety.</p> <p>There are no specific targets or indicators listed.</p>	The sustainability objectives should take account of issues relating to the safety of nuclear power stations in respect of both at nuclear sites and the wider general population.
<i>IAEA (1997) Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management</i>	<p>The joint convention was the first legal instrument aimed to address issues of safely managing spent fuel and radioactive waste on a global scale. It entered into force in June 2001. The objectives of the Joint Convention are:</p> <ul style="list-style-type: none"> ▪ To achieve and maintain a high level of safety worldwide in spent fuel and radioactive waste management; ▪ To ensure there are effective defences against potential hazards so that individuals, society and the environment are protected now and in the future; ▪ To prevent accidents with radiological consequences and to mitigate their consequences should they occur. 	The sustainability objectives should take account of issues relating to the safety of radioactive waste and spent fuel.
<i>OSPAR Commission (1992) Convention for the Protection of the Marine Environment of the North East Atlantic</i>	<p>The convention replaces the Oslo and Paris Conventions. The aim of the OSPAR convention is to prevent pollution of the marine environment by discharges from land based activities. It requires the implementation of the precautionary principal and the polluter pays principal as well as Best Available Technology (BAT) and Best Environmental Practice.</p>	The sustainability objectives should include reference to the protection of the marine environment and the use of BAT.
<i>OSPAR Commission (2003) Biodiversity and Ecosystems Strategy</i>	<p>This Strategy seeks to protect and enhance the ecosystems and the biological diversity of the maritime area, which are, or could be, affected as a result of human activities.</p> <p>No specific targets or indicators have been identified.</p>	The sustainability objectives should include reference to the protection of the maritime environment.



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
<i>OSPAR Commission (2003) Radioactive Substances Strategy</i>	<p>The Strategy sets the objective of preventing pollution of the maritime area from ionising radiation through the reduction of discharges, emissions and losses of radioactive substances. The ultimate aim is to reduce concentrations in the environment to near background values for naturally occurring radioactive substances and close to zero for radioactive substances.</p> <p>Targets include that by 2020 the Commission will ensure that discharges, emissions and losses of radioactive substances are reduced to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, emissions and losses are close to zero.</p>	The sustainability objectives should be developed to address the protection of air, land and water from radioactive substances.
<i>OSPAR Commission (2003) Hazardous Substances Strategy</i>	<p>The Strategy sets the objective of preventing pollution of the maritime area from hazardous substances through the reduction of discharges, emissions and losses. The ultimate aim is to reduce concentrations in the environment to near background values for naturally occurring substances and close to zero for man made synthetic substances.</p>	The sustainability objectives should be developed to address the protection of air, land and water from hazardous substances.
<i>OSPAR Commission (2003) Eutrophication Strategy</i>	<p>The Strategy sets the objective to combat eutrophication in the OSPAR maritime area, in order to achieve and maintain a healthy marine environment when eutrophication does not occur.</p>	The sustainability objectives should include reference to achieve and maintain a health marine environment.
<i>UNECE (2003) Kiev Protocol on Strategic Environmental Assessment</i>	<p>The Kiev protocol will augment the Espoo Convention by ensuring that individual parties integrate environmental assessment into their plans and programmes at the earliest stages. The Protocol also provides for extensive public participation in the governmental decision making process.</p> <p>Annex I and Annex II list the types of project for which Strategic Environmental Assessment (SEA) will be required, including installations solely designed for the disposal of radioactive waste (Annex I).</p>	The sustainability objectives should ensure adequate consideration of all topics listed in the protocol.
<i>United Nations (UN) (2002) World Summit on Sustainable Development, Johannesburg</i>	<p>The World Summit reaffirmed the international commitment to sustainable development. The key outcomes were the Johannesburg Declaration and a key outcomes statement. The summit sought to:</p> <ul style="list-style-type: none"> ▪ Accelerate the shift towards sustainable consumption and production with a 10-year framework of programmes of action ▪ Reverse the trend in loss of natural resources ▪ Urgently and substantially increase the global share of renewable energy ▪ Significantly reduce the rate of loss of biodiversity by 2010 <p>There are no specific targets or indicators. However, key actions include:</p> <ul style="list-style-type: none"> ▪ Greater resource efficiency ▪ Support business innovation and take up of best practice in technology and management ▪ Waste reduction and producer responsibility ▪ Sustainable consumer consumption and procurement ▪ Create a level playing field for renewable energy and energy efficiency 	The sustainability objectives should include reference to environmental protection, sustainable consumption and use of BAT.
<i>UNESCO (1971) Ramsar Convention on Wetlands of International Importance</i>	<p>The Convention's mission is the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world.</p> <p>There are no specific targets and indicators in the document, however, the general objectives of the Ramsar Strategic Plan 2003-2008 are:</p>	<i>The sustainability framework should include objectives addressing the protection of biodiversity resources and protected species and habitats.</i>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<ul style="list-style-type: none"> ▪ The wise use of wetlands: To simulate and assist all Contracting Parties to develop, adopt and use the necessary and appropriate instruments and measures to ensure the wise use of all wetlands within their territories. ▪ Wetlands of International Importance: To stimulate and support all Contracting Parties in the appropriate implementation of the Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance, including the appropriate monitoring and management of listed sites as a contribution to sustainable development. ▪ International cooperation: To promote international cooperation through the active application of the guidelines for international cooperation under the Ramsar Convention and in particular to mobilise additional financial and technical assistance for wetland conservation and wise use. ▪ Implementation capacity: To ensure that the Convention has the required implementation mechanisms, resources and capacity to achieve its mission. ▪ Membership: To progress towards the accession of all countries to the Convention. 	
<p><i>UNESCO (1972) Convention Concerning the Protection of the World Cultural and Natural Heritage</i></p>	<p>The Convention's primary aim is to provide collective assistance by the international community to protect cultural or natural heritage of outstanding interest.</p> <p>No specific targets are listed.</p>	<p>The sustainability objectives should provide due consideration to historic and cultural issues.</p>
<p><i>UN (1998) Aarhus Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental matters</i></p>	<p>The Convention addresses the need to guarantee the rights of access to information, public participation in decision-making and access to justice in environmental matters. There is a requirement for these provisions to be implemented in the Member States.</p> <p>There are no specific targets or indicators of relevance.</p>	<p>The appraisal process has to comply with the principles of the Convention.</p> <p>Enough time needs to be provided for in the sustainability assessment process to permit consultation in accordance with Aarhus requirements.</p>
<p><i>UN (1979) Bonn Convention on the Conservation of Migratory Species of Wild Animals</i></p>	<p>The aim of the convention is for contracting parties to work together to conserve terrestrial, marine and avian migratory species and their habitats (on a global scale) by providing strict protection for endangered migratory species.</p> <p>The overarching objectives are:</p> <ul style="list-style-type: none"> ▪ Promote, co-operate in and support research relating to migratory species. ▪ Endeavour to provide immediate protection for migratory species included in Appendix I. ▪ Endeavour to conclude Agreements covering the conservation and management of migratory species included in Appendix II. <p>No specific targets or objectives were identified in the document.</p>	<p>The sustainability objectives should ensure that appropriate consideration is given to the effects on fauna in the assessment.</p>
<p><i>UN (1992) Convention on Biological Diversity</i></p>	<p>This convention was one of the main outcomes of the 1992 Rio Earth Summit.</p> <p>The key objectives of the Convention are:</p> <ul style="list-style-type: none"> ▪ The conservation of biological diversity ▪ The sustainable use of its components 	<p>The protection of biodiversity sources should be a central theme of the sustainability assessment and the sustainability framework should include objectives</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<p>The fair and equitable sharing of the benefits arising from the use of genetic resources</p> <p>The achievement of the objectives in the Convention relies heavily on the implementation of action at the national level.</p>	<p>relating to the protection of biodiversity.</p>
<p><i>UN (1992) United Nations Framework Convention on Climate Change</i></p>	<p>The objective of the Convention is to prevent 'dangerous' human interference with the climate system, namely through reductions in the emissions of greenhouse gases.</p> <p>Targets include:</p> <ul style="list-style-type: none"> ▪ A 12.5% reduction by 2008-2012 of the six listed gases (carbon dioxide (CO₂); methane; nitrous oxide; hydrofluorocarbons; perfluorocarbons and sulphur hexafluoride) below 1990 levels. 	<p>The sustainability objectives will take full account of climatic and air quality issues.</p>
<p><i>UN (1998) Kyoto Protocol to the United Framework Convention on Climate Change</i></p>	<p>The Kyoto Protocol agreed in 1997 was designed to address the fact that greater cuts in emissions were needed to prevent serious interference with the climate. It has been ratified by over 166 countries. It sets legally binding emissions reductions targets on the developed countries that have ratified it (including the UK).</p> <p>In December 2007, the thirteenth Conference of Parties took place and brought together over 180 countries in Bali.</p> <p>The conference resulted in the adoption of the Bali Roadmap which consists of a number of forward-looking decisions that represent the various tracks that are essential to reaching a secure climate change future. Included in the Roadmap is the Bali Action Plan which charts the course for negotiating a new process designed to tackle climate change with the aim of completing this by 2009.</p> <p>Developed countries agreed to reduce their collective emissions of greenhouse gases by 5.2% from 1990 levels by the period 2008 to 2012. The UK target is to reduce emissions to 12.5% below 1990 levels by 2012 (note that the UK has imposed further targets on itself since then).</p> <p>Countries can achieve their Kyoto targets by:</p> <ul style="list-style-type: none"> ▪ Reducing greenhouse gas emissions in their own country. ▪ Implementing projects to reduce emissions in other countries. ▪ Trading in carbon. Countries that have achieved their Kyoto targets will be able to sell their excess carbon allowances to countries finding it more difficult or too expensive to meet their targets. 	<p>The sustainability framework should include an objective relating to the reduction of greenhouse gas emissions.</p>
<p><i>UN (2001) Stockholm Convention on Persistent Organic Pollutants (POPs)</i></p>	<p>The convention aims to eliminate or reduce the release of POPs into the environment where they have a detrimental effect are toxic to humans and wildlife.</p> <p>Relevant specific targets or objectives have not been identified.</p>	<p>The sustainability objectives should take into consideration issues relating to human health and air quality.</p>
<p><i>UN (1991) Espoo Convention on Environmental Impact Assessment in a Transboundary Context</i></p>	<p>The convention (along with the SEA protocol) has the objective to ensure that cross boundary environmental impacts of major projects are considered through appropriate consultation. It lays down the general obligation for States to notify and consult each other.</p> <p>No specific targets have been identified.</p>	<p>The assessment should consider the need for international consultation if appropriate with amendments to the sustainability objectives and criteria if necessary.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
European		
<p><i>European Union (EU) (1979) Bern Convention on the Conservation of European Wildlife and Natural Habitats</i></p>	<p>The main objectives of the Convention are to conserve wild flora and fauna and their natural habitats, especially those species and habitats whose conservation requires the co-operation of several States, and therefore the Convention promotes such co-operation.</p> <p>Particular emphasis is given to endangered and vulnerable species, including migratory species.</p> <p>In order to achieve this the Convention imposes legal obligations on contracting parties, protecting over 500 wild plant species and more than 1000 wild animal species.</p> <p>Each Contracting Party is obliged to:</p> <ul style="list-style-type: none"> ▪ Promote national policies for the conservation of wild flora, wild fauna and natural habitats, with particular attention to endangered and vulnerable species, especially endemic ones, and endangered habitats, in accordance with the provisions of this Convention. ▪ Undertake, in its planning and development policies and in its measures against pollution, to have regard to the conservation of wild flora and fauna. ▪ Promote education and disseminate general information on the need to conserve species of wild flora and fauna and their habitats. <p>No specific targets or indicators of relevance have been identified.</p>	<p>The sustainability objectives should give consideration to biodiversity, flora and fauna issues.</p>
<p><i>EU (1957) European Atomic Energy Community (EURATOM treaty) – Amended by Council Directive 96/29/EURATOM (Laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation)</i></p>	<p>The treaty was one of the founding treaties of the EU. It was drafted to address issues relating to the field of nuclear power including the protection of the work force and general public from radiation.</p> <p>The Directive defines dose limits for workers stating that the limit shall be 100 millisieverts (mSv) in a consecutive five-year period, subject to a maximum effective dose of 50 mSv in any single year and Member States may decide an annual amount.</p> <p>For members of the public, the limit for effective dose shall be 1mSv in a year. However, in special circumstances, a higher effective dose may be authorised in a single year provided that the average over five consecutive years does not exceed 1mSv per year.</p> <p>There are also limits defined for apprentices and students and during pregnancy.</p>	<p>The sustainability objectives should give consideration to the effects on human health and the environment of radioactive material.</p>
<p><i>EU (1979) Convention of European Wild Birds Directive (79/409/EEC)</i></p>	<p>This Directive relates to the conservation of all species of naturally occurring birds in the wild state in the European territory of the Member States to which the Treaty applies, including the designation of certain habitats as Special Protection Areas (SPAs). It covers the protection, management and control of these species and lays down rules for their exploitation, and also the prevention of pollution / deterioration of habitats or any disturbances affecting the birds.</p> <p>The main provisions are the maintenance of favourable conservation status of all wild bird species, the identification and classification of SPAs for rare/vulnerable species and the establishment of schemes for the protection of wild birds.</p> <p>Member States are required to define SPAs for rare or vulnerable species listed in the Directive.</p> <p>There are no specific targets or indicators of relevance.</p>	<p>The assessment should include objectives which protect biodiversity and protected species.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
<p><i>EU (1992) Convention on the Conservation of European Wildlife and of Wild Fauna and Flora (92/43/EEC) (The Habitats Directive)</i></p>	<p>The objective of the Habitats Directive is to contribute towards ensuring the conservation of natural habitats and of wild fauna and flora within the European Community.</p> <p>The target for Member States is to take measures to maintain or restore at favourable conservation status, natural habitats and species of Community importance.</p> <p>This includes Special Areas of Conservation (SAC), SPAs and it is usually accepted as also including Ramsar sites.</p> <p>These are known as European Sites.</p> <p>In undertaking these measures Member States are required to take account of economic, social and cultural requirements and regional and local characteristics.</p> <p>Plans that may adversely affect the integrity of European Sites may be required to be subject to Appropriate Assessment under the Directive.</p>	<p>The assessment should include objectives that address issues such as protection of biodiversity and habitats, and notably relate to the effects on European Designated Sites.</p>
<p><i>EU (2000) European Landscape Convention</i></p>	<p>The Convention aims to encourage public authorities to adopt policies and measures at appropriate levels to protect, manage and plan landscapes throughout Europe. The Convention proposes legal and financial measures at the national and international levels aimed at shaping landscape policies.</p> <p>No relevant specific targets or indicators have been identified.</p>	<p>The sustainability objectives should ensure that consideration is given to landscape issues during the assessment.</p>
<p><i>EU (2000) Water Framework Directive (2000/60/EC)</i></p>	<p>The purpose of this Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which:</p> <ul style="list-style-type: none"> ▪ Prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems ▪ Promotes sustainable water use based on a long-term protection of available water resources ▪ Aims to enhance protection and improvement of the aquatic environment, inter alia, through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances ▪ Ensures the progressive reduction of pollution of groundwater and prevents its further pollution ▪ Contributes to mitigating the effects of floods and droughts <p>Objectives for surface waters:</p> <ul style="list-style-type: none"> ▪ Achievement of good ecological status and good surface water chemical status by 2015 ▪ Achievement of good ecological potential and good surface water chemical status for heavily modified water bodies and artificial water bodies ▪ Prevention of deterioration from one status class to another ▪ Achievement of water-related objectives and standards for protected areas <p>Objectives for groundwater:</p> <ul style="list-style-type: none"> ▪ Achievement of good groundwater quantitative and chemical status by 2015 (quantity is a significant issue for groundwater – there is only a certain amount of re-charge into groundwater each year and this re-charge is needed to supported connected ecosystems) ▪ Prevention of deterioration from one status class to another 	<p>The assessment should include objectives that promote the protection and enhancement of the water environment. This includes water usage as well as a need to assess indirect effects such as dependent aquatic and terrestrial ecosystems and flooding.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
<p><i>EU (2002) Environmental Noise Directive (2002/49/EC)</i></p>	<ul style="list-style-type: none"> ▪ Reversal of any significant and sustained upward trends in pollutant concentrations and prevent or limit input of pollutants to groundwater ▪ Achievement of water related objectives and standards for protected areas <p>The aim of the Directive is to define a common approach intended to avoid, prevent or reduce the harmful effects including annoyance due to exposure to environmental noise.</p> <p>Each Member State is expected to determine exposure to environmental noise through noise mapping, ensure that information on environmental noise and its effects is made available to the public and to adopt action plans based on noise mapping results with a view to preventing and reducing environmental noise where necessary and particularly where exposure effects could induce harmful effects on human health.</p> <p>No specific targets or indicators have been identified.</p>	<p>The sustainability objectives should ensure that noise issues are considered in relation to human health and wider environmental receptors.</p>
<p><i>EU (2002) European Sixth Environmental Action Programme 2002-2012</i></p>	<p>The Environmental Action Programme reviews the significant environmental challenges and provides a framework for European environmental policy up to 2012.</p> <p>The four priority areas are:</p> <ul style="list-style-type: none"> ▪ Climate change ▪ Nature and biodiversity ▪ Environment and health ▪ Natural resources and waste <p>The action plan highlights that ambitious action is needed to reduce global emissions particularly after 2012 when Kyoto's targets expire. This is needed to limit global warming to 2 degrees Celsius.</p> <p>Protecting, conserving, restoring and developing the functioning of natural systems, natural habitats, wild flora and fauna is needed to halt desertification and the loss of biodiversity, including the diversity of genetic resources, both in the European Union and on a global scale.</p> <p>There is a need to contribute to the high level of quality of life for citizens by providing an environment where the level of pollution does not give rise to harmful effects on human health and the environment. Sustainable urban development should also be promoted.</p> <p>Better resource efficiency and resource and waste management is needed to bring about more sustainable production and consumption patterns, thereby de-coupling the use of resources and the generation of waste from the rate of economic growth and aiming to ensure that the consumption of renewable and non-renewable resources does not exceed the carrying capacity of the environment.</p> <p>The Action Plan introduced the concept of developing thematic strategies for particular fields that build on the existing EU regulatory framework and include new knowledge on threats to the environment and human health. The fields for which the strategies are developed are:</p> <ul style="list-style-type: none"> ▪ Air ▪ Waste prevention and recycling ▪ Marine environment ▪ Soils ▪ Pesticides ▪ Natural resources ▪ The urban environment. <p>No specific targets or indicators of relevance have been identified.</p>	<p>The assessment should include objectives that address the protection of biodiversity, adapting to climate change and the sustainable use of resources.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
<p><i>EU (2004) Environmental Liability Directive (2004/35/CE)</i></p>	<p>The Directive focuses on the prevention and remedying of environmental damage – specifically damage to habitats and species protected by European Commission (EC) law, damage to water resources and land contamination which presents a threat to human health.</p> <p>The Directive is based on the polluter pays principle. Polluters would, therefore be responsible for remediating the damage they cause to the environment or of measures to prevent imminent threat of damage.</p> <p>Local authorities would be responsible for enforcing the regime in the public interest. The Directive provides specific criteria to determine when damage is significant. Damage from nuclear and maritime accidents falls outside the scope of the regime.</p> <p>Annex I of the Directive includes criteria for determining whether effects are significant. This could be used to inform the SEA process.</p>	<p>The sustainability framework should include a number of objectives addressing environmental protection in particular recognising the need to prevent pollution to air, land and water.</p>
<p><i>EU (2005) European Climate Change Programme (ECCP II)</i></p>	<p>ECCP II follows on from ECCP I and aims to continue the EU's work to reduce climate change. It is the Commission's main instrument to discuss and prepare the further development of the EU's climate policy. The goal of the ECCP is to identify and develop all the necessary elements of an EU Strategy to implement the Kyoto Protocol making use of widespread stakeholder involvement and topic specific working groups.</p> <p>No specific targets have been identified from the programme itself.</p>	<p>The sustainability objectives should cover issues relating to climate change impacts, adaptation and emissions of greenhouse gases.</p>
<p><i>EU (2005) European Community Biodiversity Strategy (COM98/42)</i></p>	<p>The Biodiversity Strategy aims to anticipate, prevent and attack the causes of significant reduction or loss of biodiversity at the source, which will help both to reverse present trends in biodiversity decline and to place species and ecosystems, including agro-ecosystems, at a satisfactory conservation status, both within and beyond the territory of the EU.</p> <p>No specific targets or indicators have been identified.</p>	<p>The sustainability objectives should address issues relating to biodiversity, fauna and flora.</p>
<p><i>EU (2006) European Strategy for Sustainable Development</i></p>	<p>The Strategy sets out how the EU will effectively live up to its longstanding commitment to meet the challenges of sustainable development. It reaffirms the need for global solidarity and the importance of strengthening work with partners outside of the EU.</p> <p>The Strategy sets objectives and actions for seven key priority challenges until 2010. The priorities are:</p> <ul style="list-style-type: none"> ▪ Climate change and clean energy ▪ Sustainable transport ▪ Sustainable consumption and production ▪ Conservation and management of natural resources ▪ Public Health ▪ Social inclusion, demography and migration ▪ Global poverty and sustainable development challenges. <p>No specific targets or indicators of relevance have been identified.</p>	<p>The sustainability objectives should cover issues relating to sustainability (environmental, economic and social factors) in the assessment.</p>
<p><i>EU (2006) Waste Framework Directive (2006/12/EC – replaces 75/442/EEC)</i></p>	<p>The 1975 framework Directive on waste was revised by a number of amendments and a new codified version came into force in 2006.</p> <p>The Directive establishes a framework for the management of waste across the European Community. It requires Member States to:</p> <ul style="list-style-type: none"> ▪ Give priority to waste prevention and encourage re-use and recovery of waste ▪ Prohibit the uncontrolled disposal of waste ▪ Establish an integrated network of disposal installations 	<p>The sustainability objectives should ensure that the effects of a GDF on waste are adequately considered.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<ul style="list-style-type: none"> ▪ Prepare waste management plans ▪ Ensure that the cost of disposal is borne by the waste holder ▪ Ensure waste carriers are registered ▪ Ensure that waste is recovered or disposed of without endangering human health. <p>The Directive's overarching requirements are supplemented by other Directives for other waste streams.</p>	
<p><i>EC (1996) Directive on Integrated Pollution Prevention and Control (96/61/EC)</i></p>	<p>The Directive provides an integrated approach to pollution prevention. It seeks to ensure a high level of protection to the environment through measures to prevent or reduce emissions to air, water and land.</p> <p>It addresses issues relating to waste, wastewater, energy use and environmental accidents. The Directive is based on several principles including best available techniques.</p> <p>There are no specific targets or indicators of relevance.</p>	<p>The assessment framework needs to include objectives which address all of these environmental protection issues.</p>
<p><i>EC (1996) Air Quality Framework Directive (96/62/EC), and Daughter Directives (1999/30/EC), (2000/69/EC), (2002/69/EC), and (2004/107/EC)</i></p>	<p>The Framework Directive establishes a framework under which the EC will agree air quality limit values or guide values for specified pollutants in a series of Daughter Directives.</p> <p>The Directives contain limit values relating to the pollutants and it is necessary for these targets to be translated into UK legislation.</p> <p>Thresholds for pollutants are included in the Directives.</p>	<p>The SEA framework should include objectives that address the protection of air quality.</p>
<p><i>EC (1999) Landfill Directive (99/31/EC)</i></p>	<p>The Directive is intended, by way of stringent operational and technical requirements on the waste and landfills, to prevent or reduce the adverse effects of the landfill of waste on the environment, in particular on surface water, groundwater, soil, air and human health.</p> <p>The Directive establishes guidelines and targets for the quantities of biodegradable waste being sent to landfill.</p>	<p>The sustainability objectives should take account of the fact that radioactive waste will be created which will have to be managed, and should reflect this in the assessment.</p>
<p><i>EC Environmental Impact Assessment Directive (97/11/EC)</i></p>	<p>This Directive amends EIA Directive (85/337/EEC). It aims to provide an assessment of the effects of projects on the environment. The Environmental Impact Assessment (EIA) procedure ensures that environmental consequences of projects are identified and are taken into account in the authorisation procedure of the project and that the public is informed of the decision afterwards.</p>	<p>The sustainability objectives should ensure that consideration is given to the factors required to be assessed by the Directive.</p>
<p><i>EC (2001) National Emission Ceiling Directive (2001/81/EC)</i></p>	<p>This Directive sets ceilings for emissions of ammonia, oxides of nitrogen, sulphur dioxide and volatile organic compounds for member states.</p> <p>Targets include the ceiling for all four pollutants must be by 2010.</p>	<p>The sustainability objectives should include the protection of air quality.</p>
<p><i>EC (2001) Directive 2001/42/EC [The SEA Directive]</i></p>	<p>The objective is to provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adaptation of certain plans and programmes. It aims to support and promote sustainable development by ensuring that environmental assessment is carried out where there may be significant effects on the environment.</p>	<p>The sustainability objectives should ensure that adequate consideration is given to all topic areas listed in the Directive.</p>
<p><i>EC (2004) Environmental Liability Directive (2004/35/EC)</i></p>	<p>The Directive focuses on the prevention and remedying of environmental damage – specifically damage to habitats and species protected by EC law, damage to water resources and land contamination which presents a threat</p>	<p>The sustainability framework should include a number of objectives addressing environmental protection in</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<p>to human health.</p> <p>The Directive is based on the polluter pays principle. Polluters would, therefore be responsible for remediating the damage they cause to the environment or of measures to prevent imminent threat of damage. Local authorities would be responsible for enforcing the regime in the public interest.</p> <p>The Directive provides specific criteria to determine when damage is significant.</p> <p>Damage from nuclear and maritime accidents falls outside the scope of the regime.</p> <p>Annex I of the Directive includes criteria for determining whether effects are significant. This could be used to inform the SEA process.</p>	<p>particular recognising the need to prevent pollution to air, land and water.</p>
<p><i>EC (2005) Taking Sustainable Use of Resources Forwards: A Thematic Strategy on the Prevention and Recycling of Waste</i></p>	<p>This sets out guidelines for EU action and describes the ways in which waste management can be improved.</p> <p>The aim of the Strategy is to reduce the negative impact on the environment that is caused by waste throughout its life-span by focussing on reducing waste and viewing waste that is generated as a potential resource.</p> <p>No specific targets of relevance have been identified.</p>	<p>The sustainability objectives should ensure that issues relating to waste are addressed in the assessment.</p>
<p><i>EC (2006) Thematic Strategy for Soil Protection</i></p>	<p>Eight main threats to soil are identified which are:</p> <ul style="list-style-type: none"> ▪ Erosion ▪ Organic matter decline ▪ Contamination ▪ Salinisation ▪ Compaction ▪ Soil biodiversity loss ▪ Sealing ▪ Landslides and flooding. <p>The thematic Strategy calls for a framework directive and hence advocates higher levels of protection to the soil resource.</p>	<p>The assessment framework should include an objective addressing the protection of the soil resource (this is also one of the SEA Directive topics).</p>
<p><i>EC (2007) Assessment and Management of Flood Risks Directive (2007/60/EC)</i></p>	<p>This Directive sets out the requirements for all Member States to assess the risk of flooding from water courses and around coast lines, to map the flood extent, assets and humans at risk from flooding in these areas, and to take measures reduce the flood risk.</p>	<p>The sustainability objectives should include an objective addressing the risk of flooding.</p>
<p><i>EC (2009) Fuel Quality Directive (2009/30/EC)</i></p>	<p>This Directive amends Directive 98/70/EC on environmental quality standards for fuels. It aims to further tighten environmental quality standards for a number of fuel parameters, enable more widespread use of ethanol in petrol and introduce a mechanism for reporting and reduction of the life cycle greenhouse gas emissions from fuel. There is a binding target of a 6% reduction in the life cycle greenhouse gas emissions from energy supplied.</p>	<p>The sustainability objectives should include consideration to greenhouse gas emissions from fuels.</p>
<p><i>EC (2009) Promotion of the use of energy from renewable sources Directive (2009/28/EC)</i></p>	<p>This Directive amends and subsequently repeals Directives 2001/77/EC and 2003/30/EC. It highlights the EU's commitment to providing 20% of energy from renewable sources by 2020 and a mandatory 10% minimum target to be achieved by all Member States for the share of biofuels in transport petrol and diesel consumption.</p>	<p>The sustainability objectives should include consideration of renewable energy.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
National		
<p><i>Committee on Radioactive Waste Management (CoRWM) (2006) Managing our Radioactive Waste Safely</i></p>	<p>The CoRWM Report sets out the options and recommendations for the long-term management of radioactive waste. It recommends that an early closure (within a century) approach making use of geological disposal is the preferred method.</p> <p>No specific targets or indicators are set.</p>	<p>The sustainability objectives should allow for sufficient consideration of waste management in the assessment.</p>
<p><i>Department of Energy and Climate Change (DECC) (2009) Draft National Policy Statement for Nuclear Power Generation (En-6)</i></p>	<p>The National Policy Statement (NPS) sets out the Government's policy on new nuclear power generation to contribute towards the UK's energy needs and to facilitate the achievement of a low carbon economy.</p> <p>The NPS states that up to 25GW of net new energy capacity may be generated by nuclear energy, with another 35GW coming from renewable sources.</p>	<p>The sustainability objectives should have consideration of energy demand during the lifetime of the project.</p>
<p><i>Defra, Department for Business, Enterprise and Regulatory Reform (BERR), Department of the Environment Northern Ireland (DoENI) and Welsh Assembly Government (2008) Managing our Radioactive Waste Safely: A framework for Implementing Geological Disposal.</i></p>	<p>The White Paper sets out the UK Government's framework for managing higher activity radioactive waste in the long-term through geological disposal coupled with safe and secure interim storage and ongoing research and development to support its optimised implementation. It also invites communities to express an interest in opening up without commitment discussions with Government on the possibility of hosting a geological disposal facility at some point in the future.</p>	<p>Geological disposal concepts arise from the objectives set out in the White Paper.</p> <p>The SEA should have regard as to the contribution a GDF makes towards the implementation of the MRWS.</p>
<p><i>Department for Culture, Media and Sport (DCMS) (2001) The Historic Environment: A Force for Our Future</i></p>	<p>This document provided a thorough review of Government policy in place to protect the historic environment. It sets out a list of key actions including providing leadership to protect the historic environment, realise the educational potential of assets, involve people and protect and sustain the historic environment.</p> <p>No specific targets of relevance have been identified.</p>	<p>The sustainability objectives should ensure that the historic environment is fully considered in the assessment of a GDF.</p>
<p><i>DCMS and Welsh Assembly Government (2007) Heritage Protection for the 21st Century</i></p>	<p>The White Paper reflects the importance of preserving the country's heritage. The methods of preservation are based on three core principles:</p> <ul style="list-style-type: none"> ▪ Developing a unified approach to the historic environment ▪ Maximising opportunities for inclusion and involvement ▪ Supporting sustainable communities by putting the historic environment at the heart of an effective planning system. <p>The White Paper proposes to create a single system for designation among other measures.</p> <p>No specific targets of relevance have been identified.</p>	<p>The sustainability objectives should ensure appropriate consideration is given to the historic environment in the assessment.</p>
<p><i>Defra (2002) UK Strategy for Radioactive Discharges</i></p>	<p>The Strategy implements the agreements reached at the Ministerial meeting and subsequent meeting of the OSPAR Commission as set out in the OSPAR Strategy with regard to radioactive substances.</p> <p>It provides a basis for the review of future discharge authorisations and for strategic planning by nuclear operators.</p> <p>The Strategy does not set individual limits for radioactive discharges but</p>	<p>The sustainability objectives should include reference and consideration of the protection of environmental resources from radiological discharges.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
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establishes a strategic framework for discharges from UK installations over the next 20 years. The aims are:

- A progressive and substantial reduction of radioactive discharges and discharge limits.
- A progressive reduction in human exposure to ionising radiation arising from radioactive discharges, such that a representative member of a critical group of the general public will be exposed to an estimated mean dose of no more than 0.02millisieverts (mSv) a year from liquid radioactive discharges to the marine environment made from 2020 onwards.
- A progressive reduction of concentrations of radionuclides in the marine environment resulting from radioactive discharges such that by 2020 they add close to zero to historic levels.

The As Low As Reasonably Achievable (ALARA) principle is followed in the UK whereby radiological doses and risks are kept ALARA taking into account the balance between radiological and other factors including social and economic issues.

Key targets include:

- Nuclear energy production – By 2020 total beta/gamma discharges (excluding tritium) are expected to be reduced from more than 10TBq to less than 1.5TBq a year. Discharges of tritium are expected to be reduced from more than 2800TBq to about 850TBq a year.

At the time of writing a revised discharge strategy being reviewed by DECC (who now have policy accountability for this area) and the devolved administrations following a consultation in 2008.

Defra (2003) Sites of Special Scientific Interest (SSSI): Encouraging Positive Partnerships

The Government's aim is to emphasise the importance of positive management of SSSIs through improved, constructive relationships between the landowners, managers and officers of the conservation agencies.

The documents aims to:

- Improve the procedures for notifying sites of national nature conservation and earth heritage importance as SSSIs, and emphasise the importance attached to such sites
- Provide better protection for SSSIs from operations that damage, or are likely to damage, the special interest, and secure sympathetic management, by both public and private landowners, which contributes to the conservation of the special features on individual SSSIs.

No specific targets have been identified.

The sustainability objectives should take full account of the potential effect of the Strategy on designated sites for the protection of biodiversity, fauna, flora, geology and soils, including SSSI, SAC, SPA and Ramsar areas.

Defra (2004) Rural Strategy

The Strategy sets out the Governments approach to meet rural challenges. It identifies three key priorities for rural:

- Economic and Social Regeneration – supporting enterprise across rural England, but targeting greater resources at areas of greatest need.
- Social Justice for All – tackling rural social exclusion wherever it occurs and providing fair access to services and opportunities for all rural people.
- Enhancing the value of our Countryside – protecting the natural environment for this and future generations.

These priorities will inform the Government's rural policy for the next three to five years and the modernised delivery arrangements that will drive progress forward. This Strategy sets out the specific action that will be taken.

There are no targets or indicators of relevance.

The sustainability objectives should reflect the aims of the Rural Strategy relating to the sustainable development of rural areas and maintaining the quality and character of the rural environment.



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
<p><i>Defra (2005) Making Space for Water – Taking forward a new Government Strategy for flood and coastal erosion risk management in England</i></p>	<p>This document sets out the Government’s response to the need for a comprehensive, integrated and forward thinking Strategy for managing future flood and coastal erosion risks in England over the 20 years.</p> <p>The aim of the Strategy is to manage the risks from flooding and coastal erosion by employing an integrated portfolio of approaches which reflect both national and local priorities, so as:</p> <ul style="list-style-type: none"> ▪ To reduce the threat to people and their property ▪ To deliver the greatest environmental, social and economic benefit consistent with the Government’s sustainable development principles. <p>No specific targets have been set out in the document.</p>	<p>The sustainability objectives should ensure that necessary consideration is given to the potential effects of climate change and flood risk as a result of implementing a GDF.</p>
<p><i>Defra (2005) Securing the Future – The UK Government Sustainable Development Strategy</i></p>	<p>The Strategy for sustainable development aims to enable all people throughout the world to satisfy their basic needs and enjoy a better quality of life without compromising the quality of life of future generations.</p> <p>As a result of the 2004 consultation to develop new UK sustainable development Strategy, the following issues have been highlighted as the main priority areas for immediate action:</p> <ul style="list-style-type: none"> ▪ Sustainable consumption and production – working towards achieving more with less ▪ Climate change and energy – confronting the greatest threat ▪ Natural resource protection and environmental enhancement – protecting the natural resources on which we depend ▪ From local to global – building sustainable communities – creating places where people want to live and work, now and in the future. <p>In addition to these four priorities, changing behaviour also forms a large part of the Government’s thinking on sustainable development. The following principles will be used to achieve the sustainable development purpose, and have been agreed by the UK Government, Scottish Government, Welsh Assembly Government, and the Northern Ireland Administration:</p> <ul style="list-style-type: none"> ▪ Living within environmental limits ▪ Ensuring a strong, healthy, and just society ▪ Achieving a sustainable economy ▪ Promoting good governance ▪ Using sound science responsibly. <p>The Shared Framework For Sustainable Development identifies the shared goals for the UK that devolved administrations need to work towards. They are:</p> <ul style="list-style-type: none"> ▪ Sustainable consumption and production ▪ Climate change and energy ▪ Natural resource protection and environmental enhancement ▪ Sustainable Communities. <p>Although there are no specific targets within this Strategy, it makes reference to targets set in related Public Service Agreements (PSA) and other relevant policy statements.</p> <p>It also lists 68 high level UK Government Strategy indicators, which will be used to measure the success with which the above objectives are being met. The most relevant to this study are:</p> <ul style="list-style-type: none"> ▪ Greenhouse gas emissions: Kyoto target and CO₂ emissions ▪ CO₂ emissions by end user: industry, domestic, transport (excluding international aviation), other ▪ Renewable electricity: renewable electricity generated as a percentage of total electricity ▪ Energy supply: UK primary energy supply and gross inland energy 	<p>The sustainability objectives should ensure that consideration is given to the effects of a GDF on the indicators identified by the Government’s Strategy.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<ul style="list-style-type: none"> consumption ▪ Water resource use: total abstractions from non-tidal surface and ground water sources ▪ Waste: arisings by (a) sector (b) method of disposal ▪ Bird populations: bird population indices (a) farmland birds (b) woodland birds (c) birds of coasts and estuaries (d) wintering wetland birds ▪ Biodiversity conservation: (a) priority species status (b) priority habitat status ▪ River quality: rivers of good (a) biological (b) chemical quality ▪ Air quality and health: (a) annual levels of particles and ozone (b) days when air pollution is moderate or higher. 	
<p><i>Defra (2006) Climate Change – The UK Programme 2006: Tomorrow's Climate Today's Challenge</i></p>	<p>This document sets out commitments to help achieve the national goal of reducing carbon dioxide by 20% below 1990 levels by 2010 and 60% by 2050.</p> <p>Targets include the 20% reduction in CO₂ emissions by 2010 and a 60% reduction by 2050.</p>	<p>The sustainability objectives should facilitate the consideration of changes in greenhouse gas emissions arising from the implementation of a GDF.</p>
<p><i>Defra (2007) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland</i></p>	<p>This Strategy sets out air quality objectives and policy options to further improve air quality in the UK from today into the long-term. As well as direct benefits to public health, these options are intended to provide important benefits to quality of life and help to protect our environment.</p> <p>This updated Strategy provides a clear, long-term vision for improving air quality in the UK and offers options for further consideration to reduce the risk to health and the environment from air pollution. It sets out a way forward for work and planning on air quality issues, details objectives to be achieved, and proposes measures to be considered further to help reach the objectives.</p> <p>This review of the previous Air Quality Strategy (2003) proposes potential new policy measures to improve air quality, and examines their costs and benefits, the impact on exceedences of the Strategy's air quality objectives, the effect on ecosystems and also the qualitative impacts.</p> <p>This Strategy sets out an agenda for the longer-term, in particular the need to find out more about how air pollution impacts on people's health and the environment, to help inform options and future policy decisions. It sets out a framework to achieve cleaner air that will bring health and social benefits.</p> <p>The Strategy sets objectives and targets for each air quality pollutant, e.g. to achieve and maintain 40 microgram m⁻³ of annual average nitrogen dioxide.</p>	<p>The sustainability objectives should enable sufficient consideration of the likely effects on air quality as a result of the implementation of a GDF.</p>
<p><i>Defra (2007) Waste Strategy for England 2007</i></p>	<p>The Strategy aims to reduce waste by making products with fewer natural resources. It highlights out the link between economic growth and waste growth must be broken and that most products should be re-used or their materials recycled while energy should be recovered where possible. It also recognises that land filling of residual waste in small amounts may still be necessary.</p> <p>The Government's key objectives are:</p> <ul style="list-style-type: none"> ▪ To decouple waste growth form economic growth. ▪ Meet and exceed the Landfill Directive diversion targets for biodegradable municipal waste in 2010, 2013 and 2020. ▪ Increase diversion from landfill of non-municipal waste and secure better integration of treatment for municipal waste and secure better integration of treatment for municipal and non-municipal waste. ▪ Secure the investment in infrastructure needed to divert waste from landfill and for the management of hazardous waste. 	<p>The assessment should include objectives that ensure waste issues are considered in the assessment.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<ul style="list-style-type: none"> Get the most environmental benefit from investment through increased recycling of resources and recovery of energy from residual waste using a mix of technologies. <p>The Strategy includes targets for reducing household waste production but these are not relevant to this plans and programmes review. The Strategy expects a reduction of commercial and industrial waste going to landfill by at least 20% by 2010 compared to 2004.</p>	
<p><i>Department of the Environment, Transport and the Regions (2000) Revitalising Health and Safety</i></p>	<p>The aims of the Strategy are to:</p> <ul style="list-style-type: none"> Inject new impetus into the health and safety agenda Identify new approaches to reduce further rates of accidents and ill health caused by work, especially approaches relevant to small firms Ensure that our approach to health and safety regulation remains relevant for the changing world of work over the next 25 years Gain maximum benefit from links between occupational health and safety and other Government programmes. <p>Targets include:</p> <ul style="list-style-type: none"> To reduce the number of working days lost per 100,000 workers from work-related injury and ill health by 30% by 2010 To reduce the incidence rate of fatal and major injury accidents by 10% by 2010 To reduce the incidence rates of cases of work-related ill health by 20% by 2010. 	<p>The assessment should include objectives that consider the effects of a GDF towards achieving the targets set out in this Strategy along with wider health and safety issues.</p>
<p><i>DoENI (2002) Northern Ireland Biodiversity Strategy</i></p>	<p>The Strategy sets out a series of actions to protect and enhance biodiversity in Northern Ireland. It presents 76 recommendations aimed at halting the loss of biodiversity from Northern Ireland by 2016. The majority of recommendations are for the Government to achieve.</p> <p>No specific targets of relevance have been identified.</p>	<p>The sustainability objectives should ensure full consideration is given to the likely effects of geological disposal concepts on biodiversity.</p>
<p><i>DoENI (2006) Integrated Coastal Zone Management Strategy for Northern Ireland 2006 -2026</i></p>	<p>The Strategy sets out the shared vision for Northern Ireland's coastal zone. It proposes a coastal zone which through an ecosystem approach and the sustainable management of natural and built resources supports a vibrant, viable and informed population.</p> <p>It is intended to form the basis of a new approach to management of the coastal area, determining how best to target resources and environmental needs.</p> <p>There are a number of targets included in the Strategy which are designed to monitor progress towards the aims and objectives cited in the Strategy. Some of them are considered too detailed and too specific for inclusion in this SEA but key high level high level targets of relevance include:</p> <ul style="list-style-type: none"> To maintain and improve water quality To achieve good ecological and good chemical status as defined in the Water Framework Directive. 	<p>Appropriate sustainability objectives should be incorporated to ensure due consideration is given to the quality of water in the marine environment.</p>
<p><i>Department of Trade and Industry (DTI) (2003) Our Energy Future: Creating a Low Carbon Economy White Paper (now embodied by the Energy Act 2004)</i></p>	<p>The White Paper sets out the proposed new energy policy designed to address the challenges of climate change, energy security and dated infrastructure, while shifting the UK to a low carbon economy.</p> <p>The objective us to:</p> <ul style="list-style-type: none"> Put the UK on a path to cut its CO₂ emissions by some 60% by 2050, with real progress by 2020 Maintain the reliability of energy supplies Promote the competitive markets in the UK and beyond, helping raise 	<p>Sustainability objectives should be included that relate to the consumption of energy and use of low carbon, renewable energy sources.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<p>the rate of sustainable economic growth</p> <ul style="list-style-type: none"> Ensure every home is adequately and affordably heated. <p>The main targets of the White Paper is for renewable energy sources to generate 10% of energy by 2010 and around 20% by 2020, and that nobody in Britain should be living in fuel poverty by 2016-2018.</p>	
<p><i>DTI (2007) Meeting the Energy Challenge – A White Paper on Energy</i></p>	<p>The White Paper sets out the Government’s international and domestic energy Strategy to respond to changing circumstances with respect to tackling climate change and ensuring secure, clean and affordable energy as we become increasingly dependent on imported fuel. It addresses the long-term energy challenges faced and delivers four energy policy goals:</p> <ul style="list-style-type: none"> To put ourselves on a path to cutting CO₂ emissions by some 60% by 2050 with real progress by 2020 To maintain the reliability of energy supplies To promote competitive markets in the UK and beyond To ensure that every home is adequately and affordably heated. <p>Since the publication of this white paper the Department for Business, Enterprise and Regulatory Reform (BERR) have published a number of consultation on the Strategic Siting Assessment Process and Siting Criteria for New Nuclear Power Stations in the UK.</p>	<p>Sustainability objectives should be included that relate to the consumption of energy and use of low carbon, renewable energy sources.</p>
<p><i>Environment Agency (EA) (2001) Water Resources for the Future – A Strategy for England and Wales</i></p>	<p>The Strategy seeks to promote water efficiency four households, commerce and industry It recommends that further attention be paid to leakage control.</p> <p>Targets include Enhancement of water supply by up to 1,100 Ml/d above present levels through the improvement of existing schemes and the development of some new resources.</p>	<p>The assessment should include objectives that address issues relating to water consumption and water resources.</p>
<p><i>Environment and Heritage Service Northern Ireland (2006) Towards Resource Management – The Northern Ireland Waste Management Strategy</i></p>	<p>The Strategy sets out the vision and measures to implement Northern Ireland’s waste management until 2020.</p> <p>Targets include:</p> <ul style="list-style-type: none"> 60% of Commercial and Industrial Waste to be recycled by 2010 75% of Construction, Demolition and Excavation Wastes to be recycled or reused by 2020. 	<p>The assessment should include objectives that relate to issues of waste and the management of waste generated.</p>
<p><i>Health and Safety Executive (HSE) (2000) Securing Health Together</i></p>	<p>The Strategy represents a joint commitment by relevant Government bodies and other interested parties outside Government, to work together to reach the following common goals:</p> <ul style="list-style-type: none"> Reduce ill health both in workers and the public caused, or made worse, by work Help people who have been ill, whether caused by work or not, to return to work Improve work opportunities for people currently not in employment due to ill health or disability Use the work environment to help people maintain or improve their health. <p>The Strategy includes the following targets:</p> <ul style="list-style-type: none"> A 20% reduction in the incidence of work-related ill health A 20% reduction in ill health to members of the public caused by work activity A 30% reduction in the number of work days lost due to work-related ill health. 	<p>The SEA should include objectives that address issues relating to health and safety at work, and wider human health.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
<p><i>HSE (2004) A Strategy for Workplace Health and Safety in Great Britain to 2010 and Beyond</i></p>	<p>The Strategy sets out the vision for workplace health and safety in Great Britain as gaining recognition of health and safety as a corner stone of a civilised society and, with that, to achieve a record of workplace health and safety that leads the worlds. New aims identified in the Strategy include:</p> <ul style="list-style-type: none"> ▪ Developing new ways to establish and maintain an effective health and safety culture in a changing economy, so that all employers take their responsibilities seriously, the workforce is involved and risks are properly managed. ▪ Do more to address the new and emerging work-related health issues. ▪ Achieve higher levels of recognition and respect for health and safety as an integral part of a modern, competitive business and public sector and as a contribution to social justice and inclusion. <p>No specific targets of relevance are contained in the report.</p>	<p>The sustainability objectives should ensure that health and safety of the workforce is sufficiently addressed in the assessment.</p>
<p><i>Highlands and Islands Enterprise (2005) A Smart, Successful Highlands and Islands: An Enterprise Strategy for the Highlands and Islands of Scotland</i></p>	<p>The Strategy carries forward the strategic objectives of the national enterprise Strategy, together with its two cross-cutting themes of sustainable development and closing the opportunity gap.</p> <p>Aspirational targets set out in the Strategy include:</p> <ul style="list-style-type: none"> ▪ Aiming to become a region of half a million residents in twenty years' time. ▪ The region should seek to create a further 20,000 or so full-time equivalent jobs over that period. ▪ The region should raise income levels by 10-15% in real terms. ▪ The region should contribute to building a smart successful Scotland by being an international shop window for the best our country has to offer. 	<p>Recognition of the need for embedded principals of sustainable development as well as economic growth in more rural areas should be reflected within the sustainability objectives.</p>
<p><i>Historic Scotland (2002) Passed to the Future – Historic Scotland's Policy for the Sustainable Management of the Historic Environment</i></p>	<p>This sets out the policy for the sustainable management of Scotland's historic environment. The underlying theme of the policy stresses the value of retaining, and, where it is possible and right to do so, re-using existing structures and materials.</p> <p>No specific targets of relevance are contained within the document.</p>	<p>The sustainability objectives should encourage the full consideration of the effects of a GDF on the historic environment, in both landscape and built heritage terms.</p>
<p><i>Historic Scotland (2007) Scotland's Historic Environment – Scottish Historic Environment Policy 1</i></p>	<p>This is an overarching policy statement for the historic environment and provides a more detailed framework for comprehensive strategic and operational policies that inform the day-to-day work of a range of organisations that have a role and interest in managing the historic environment.</p> <p>The document is intended to complement the Scottish Planning Policy Series and other Ministerial policy documents. The vision seeks to achieve the following:</p> <ul style="list-style-type: none"> ▪ To realise the historic environment's full potential as an economic, educational and cultural resource across every part of Scotland and by the widest range of people. ▪ To maximise the role of the historic environment in achieving the wider aims of social and economic regeneration. ▪ To identify what shapes the historic environment and to protect and manage it to guarantee its long-term survival. ▪ To break down the intellectual and physical barriers to its wider accessibility. ▪ Investing in the delivery of the strategic policy framework for the historic environment. ▪ To ensure that the historic environment is cared for, and protected and enhanced to benefit current and future generations. 	<p>The sustainability objectives should enable full consideration of the effects of a GDF on the historic environment.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<ul style="list-style-type: none"> ▪ To increase appreciation and enjoyment of the historic environment. ▪ To increase recognition of the historic environment's importance as a key asset in Scotland's economic, social and cultural success. <p>No specific targets of relevance are contained within the document.</p>	
<p><i>Historic Scotland (2006) Scheduling: Protecting Scotland's Nationally Important Monuments – Scottish Historic Environment Policy 2</i></p>	<p>The document sets out the policy on scheduling monuments in Scotland and therefore relates to higher level policy approaches. The document emphasises the importance of protecting scheduled monuments and protecting the historic environment. The value of monuments as part of Scotland's identity is also highlighted. Care should be taken to ensure that scheduled monuments are not needlessly damaged or destroyed.</p> <p>No specific targets of relevance have been identified.</p>	<p>The assessment should contain objectives that take account of the historic environment.</p>
<p><i>HM Government (1979) Ancient Monuments and Archaeological Areas Act</i></p>	<p>The Act's purpose is to consolidate and amend the law relating to ancient monuments, to make provision for the investigation, preservation and recording of matters of archaeological or historic interest and for the regulation of operations or activities affecting such matters.</p> <p>No specific targets are contained in the Act.</p>	<p>The sustainability objectives should address issues relating to the preservation of the historic environment.</p>
<p><i>HM Government (1990) Environmental Protection Act</i></p>	<p>The Act's purpose is to make provision for the improved control of pollution arising from certain industrial and other processes, extend the coverage of the Clean Air Acts, to amend the law relating to litter and wastes, to amend the Radioactive Substances Act (1964), to make provision for the control of GM organisms and generally lay out protective measures for the environment.</p> <p>No specific targets of relevance were identified.</p>	<p>The sustainability objectives should address issues relating to the protection of the environment (including terrestrial, atmospheric, and aquatic elements).</p>
<p><i>HM Government (1990) Planning (Listed Buildings and Conservation Areas) Act</i></p>	<p>The Act's purpose is to consolidate certain enactments relating to special controls of buildings and areas of special architectural or historic interest with amendments to give effect to recommendations of the Law Commission.</p> <p>No specific targets of relevance have been identified.</p>	<p>The sustainability objectives should ensure consideration of the effects of a GDF on historic architectural features.</p>
<p><i>HM Government (1994) Biodiversity – The UK Action Plan</i></p>	<p>This Plan has been prepared in response to Article 6 of the Biodiversity Convention. The aim of the Action Plan is to conserve and enhance biological diversity within the UK and to contribute to the conservation of global biodiversity through all appropriate mechanisms.</p> <p>The objectives for conserving biodiversity include:</p> <ul style="list-style-type: none"> ▪ To conserve and where practicable to enhance the overall populations and natural ranges of native species, internationally important and threatened species, habitats and ecosystems. ▪ To increase public awareness of, and involvement in, conserving biodiversity. ▪ To contribute to the conservation of biodiversity on a European and global scale. <p>The plan contains 391 action plans for 381 priority species and 10 priority species-groups. Individual plans have been developed for 45 priority habitats. Specific targets are established for each of these action plans which are regarded as being too detailed for listing in this review, although will be considered as necessary in the SEA.</p>	<p>The sustainability objectives should ensure that biodiversity and the protection of fauna and flora species is suitably addressed in the assessment.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
<i>HM Government (2004) Planning and Compulsory Purchase Act</i>	The Act aims to strengthen the focus on sustainability, transparency, flexibility and speed of the planning process. It sets out the requirements for Regional Spatial Strategies for the regions, Local Development Documents as well as simplified planning zones and planning contribution. It also requires that any plans and programmes required by the Act contribute to sustainable development.	The sustainability objectives should ensure that consideration is given to plans and programmes and the contribution to sustainable development.
<i>HM Government (2006) Natural Environment and Rural Communities Act</i>	The Act's purpose is to make provision for and establish Natural England, and to make provision in connection with wildlife, SSSIs, National Parks and Broads. No specific targets have been identified.	The sustainability objectives should ensure that the appropriate consideration is given to the environmental issues such as biodiversity and designated sites.
<i>HM Government (2008) Climate Change Act</i>	The Act sets a legally binding long-term framework for the reduction of carbon emissions by 80% below 1990 levels by 2050.	The sustainability objectives should ensure that the effects on climate change and carbon emissions by a GDF are taken into account.
<i>HM Government (2008) Planning Act</i>	The Planning Act introduced a new stream-lined system for decisions on applications to build nationally significant infrastructure projects in England and Wales, alongside further reforms to the town and country planning system and the introduction of a Community Infrastructure Levy. The Act establishes the Infrastructure Planning Commission and a series of National Policy Statements to cover nationally significant infrastructure.	The sustainability objectives should have regard to the new planning process for nationally significant infrastructure.
<i>Office of the Deputy Prime Minister (ODPM) (2005) Planning Policy Statement (PPS) 1: Delivering Sustainable Development</i>	PPS1 sets out the Government's overarching planning policies on the delivery of sustainable development through the planning system. The Government set out four aims for sustainable development in its 'A Better Quality of Life - A Strategy for Sustainable Development for the UK' (1999). These are: <ul style="list-style-type: none"> ▪ Social progress which recognises the needs of everyone ▪ Effective protection of the environment ▪ The prudent use of natural resources ▪ The maintenance of high and stable levels of economic growth and employment. <p>These aims should be pursued in an integrated way through a sustainable, innovative and productive economy that delivers high levels of employment, and a just society that promotes social inclusion, sustainable communities and personal well being, in ways that protect and enhance the physical environment and optimise resource and energy use.</p>	The effects of a GDF in relation to achieving sustainable development should be considered.
<i>Department for Communities and Local Government (DCLG) (2010) PPS5: Planning for the Historic Environment</i>	PPS5 sets out the Government's national policies on different aspects of spatial planning in England. The Government's overarching aim is that the historic environment and its heritage assets should be conserved and enjoyed for the quality of life they bring to this and future generations. To achieve this, the PPS's objectives for planning for the historic environment are to deliver sustainable development by recognising the social, economic and environmental benefits of conservation of a non-renewable resource, and to conserve England's heritage assets in a manner appropriate to their significance by ensuring that their contribution is recognised and valued.	The sustainability objectives should enable full consideration of the effects of the NDA's Strategy on the historic environment.



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
<p><i>English Heritage (2010) Strategic Environmental Assessment, Sustainability Appraisal and The Historic Environment</i></p>	<p>This document sets out an approach for considering the historic environment in SEA and SA at each stage of the assessment process.</p>	<p>The sustainability objectives should ensure the historic environment is adequately considered.</p>
<p><i>ODPM (2004) PPS7: Sustainable Development in Rural Areas</i></p>	<p>PPS7 sets out the Government's planning policies for rural areas, including country towns and villages and the wider, largely undeveloped countryside up to the fringes of larger urban areas. The PPS highlights the Government's objectives for rural areas that are relevant. These include:</p> <ul style="list-style-type: none"> ▪ Increase the quality of life and the environment in rural areas through the promotion of, e.g. sustainable rural communities, sustainable economic growth / diversification, sustainable development that respects and, where possible, enhances local distinctiveness and the countryside quality, and protection of the countryside. ▪ Promotion of sustainable patterns of development, e.g. preventing urban sprawl, focussing development in, or next to, existing towns / villages, and discouraging development of 'greenfield' land etc. ▪ Promotion of the development of the English regions by improving their economic performance, e.g. by developing competitive, diverse and thriving rural enterprise that provides a range of jobs and underpins strong economies. ▪ Promotion of sustainable, diverse and adaptable agriculture sectors where farming achieves high environmental standards and contributes both directly and indirectly to rural economic diversity. 	<p>The SEA should include objectives relating to the protection and sustainable development of rural areas.</p>
<p><i>ODPM (2005) PPS9: Biodiversity and Geological Conservation</i></p>	<p>The Governments objectives for Planning with respect to conserving and enhancing biodiversity are set out in this PPS. These are:</p> <ul style="list-style-type: none"> ▪ To promote sustainable development by ensuring that biological and geological diversity are conserved and enhanced as an integral part of social, environmental and economic development, so that policies and decisions about the development and use of land integrate biodiversity and geological diversity with other considerations ▪ To conserve, enhance and restore the diversity of England's wildlife and geology by sustaining, and where possible improving, the quality and extent of natural habitat and geological and geomorphological sites; the natural physical processes on which they depend; and the populations of naturally occurring species which they support ▪ To contribute to rural renewal and urban renaissance by enhancing biodiversity in green spaces and among developments so that they are used by wildlife and valued by people, recognising that healthy functional ecosystems can contribute to a better quality of life and to people's sense of well-being, and ensuring that developments take account of the role and value of biodiversity in supporting economic diversification and contributing to a high quality environment. 	<p>The SEA framework should contain objectives relating to the protection of biodiversity and geological resources.</p>
<p><i>ODPM (2005) PPS10: Planning for Sustainable Waste Management</i></p>	<p>Positive planning has an important role in delivering sustainable waste management through the development of appropriate strategies for growth, regeneration and the prudent use of resources, and by providing sufficient opportunities for new waste management facilities of the right type, in the right place and at the right time. Key targets for Local authorities are:</p> <ul style="list-style-type: none"> ▪ Help deliver sustainable waste management through driving waste management up the waste hierarchy, addressing waste as a resource and looking to disposal as the last option but one which must be catered for ▪ Provide a framework in which communities take more responsibility for their own waste 	<p>The SEA framework should contain objectives relating to the amount of waste produced during the decommissioning process and attempt to process this as high up the waste hierarchy as possible.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<ul style="list-style-type: none"> ▪ Help implement the national waste Strategy, and supporting targets ▪ Help secure the recovery or disposal of waste without endangering human health and without harming the environment ▪ Reflect the concerns and interests of communities, the needs of waste collection authorities, waste disposal authorities, business, and encourage competitiveness ▪ Protect greenbelts but recognise the particular locational needs of some types of waste management facilities when defining detailed greenbelt boundaries and in determining planning applications. These locational needs, together with the wider environmental and economic benefits of sustainable waste management, are material considerations that should be given significant weight in determining whether proposals should be given planning permissions ▪ Ensure the design and layout of new development supports sustainable waste management. 	
<p><i>ODPM (2001) PLanning Policy Guidance (PPG) 13: Transport</i></p>	<p>PPG13 aims to integrate planning and transport at the national, regional, strategic and local level to:</p> <ul style="list-style-type: none"> ▪ Promote more sustainable transport choices for both people and for moving freight ▪ Promote accessibility to jobs, shopping, leisure facilities and services by public transport, walking and cycling ▪ Reduce the need to travel, especially by car. 	<p>The SEA should contain objectives that support sustainable transport and enable the assessment of the effects of a GDF on the strategic transport network.</p>
<p><i>ODPM (2004) PPS22: Renewable Energy</i></p>	<p>This document sets out the Government's planning policies for renewable energy, which planning authorities should have regard to when preparing local development documents and when taking planning decisions.</p> <p>Objectives include:</p> <ul style="list-style-type: none"> ▪ Social progress which recognises the needs of everyone by contributing to the nation's energy needs, ensuring all homes are adequately and affordably heated; and providing new sources of energy in remote areas ▪ Effective protection of the environment - by reductions in emissions of greenhouse gases and thereby reducing the potential for the environment to be affected by climate change ▪ Prudent use of natural resources - by reducing the nation's reliance on ever diminishing supplies of fossil fuels ▪ Maintenance of high and stable levels of economic growth and employment - through the creation of jobs directly related to renewable energy developments, but also in the development of new technologies. In rural areas, renewable energy projects have the potential to play an increasingly important role in the diversification of rural economies. 	<p>The SEA should give consideration of the effects of a GDF in relation to the use of renewable energy.</p>
<p><i>ODPM (2004) PPS23: Planning and Pollution Control</i></p>	<p>The PPS requires that international environmental and pollution control obligations are met, whilst at the same time meeting sustainable development objectives and applying the precautionary principle in considering development documents. This Statement advises that:</p> <ul style="list-style-type: none"> ▪ Any consideration of the quality of land, air or water and potential impacts arising from development, possibly leading to impacts on health, is capable of being a material planning consideration, in so far as it arises or may arise from or may affect any land use ▪ The planning system plays a key role in determining the location of development which may give rise to pollution, either directly or indirectly, and in ensuring that other uses and developments are not, as far as possible, affected by major existing or potential sources of 	<p>The SEA should contain objectives, indicators and targets that relate to pollution control. Pollution from the decommissioning process is an issue which would need to be carefully considered and mitigated as there could be adverse impacts for human health and a range of other environmental receptors e.g. air, land and</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<p>pollution</p> <ul style="list-style-type: none"> ▪ The controls under the planning and pollution control regimes should complement rather than duplicate each other ▪ The presence of contamination in land can present risks to human health and the environment, which adversely affect or restrict the beneficial use of land but development presents an opportunity to deal with these risks successfully ▪ Contamination is not restricted to land with previous industrial uses, it can occur on greenfield as well as previously developed land and it can arise from natural sources as well as from human activities ▪ Where pollution issues are likely to arise, intending developers should hold informal pre-application discussions with the Local Planning Authority (LPA), the relevant pollution control authority and/or the environmental health departments of LPAs, and other authorities and stakeholders with a legitimate interest ▪ Where it will save time and money, consideration should be given to submitting applications for planning permission and pollution control permits in parallel and co-ordinating their consideration by the relevant authorities. 	<p>water.</p>
<p><i>ODPM (2006) PPS25: Development and Flood Risk</i></p>	<p>PPS25 sets out Government policy on development and flood risk. Its aims are to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas of highest risk.</p> <p>Where new development is, exceptionally, necessary in such areas, policy aims to make it safe, without increasing flood risk elsewhere, and, where possible, reducing flood risk overall. Regional Planning Bodies and local planning authorities should prepare and implement planning strategies that help to deliver sustainable development by:</p> <ul style="list-style-type: none"> ▪ Identifying land at risk and the degree of risk of flooding from river, sea and other sources in their areas ▪ Preparing regional or strategic flood risk assessments as appropriate either as part of the Sustainability Appraisal of their plans or as a freestanding document that contributes to that appraisal. ▪ Framing policies for the location of development which avoids flood risk to people and property where possible, and manage any residual risk, taking account of the impacts of climate change. ▪ Only permitting development in areas of flood risk when there are no reasonably available sites in areas of lower flood risk and benefits of the development outweigh the risks from flooding ▪ Safeguarding land from development that is required for current and future flood management e.g. conveyance and storage of flood water, and flood defences ▪ Reducing flood risk to and from new development through location, layout and design, incorporating sustainable drainage systems. 	<p>The SEA needs to include objectives relating to flood risk and the need to manage runoff effectively. The baseline data collection process should gather information about the location of coastal and fluvial flood risk areas.</p>
<p><i>ODPM (2003) Sustainable Communities – Building for the Future</i></p>	<p>This action programme marks a step change in the policies for delivering sustainable communities for all. The plan details measures to tackle the housing provision mismatch between the South-East and parts of the North and the Midlands, with more imaginative design and the sustainment of an agreeable and convenient environment.</p> <p>It is part of the Government's wider drive to raise the quality of life in communities through increasing prosperity, reducing inequalities, providing more employment, better public services, better health and education, tackling crime and antisocial behaviour, and much more.</p>	<p>The SEA should include objectives addressing the protection of biodiversity and other environmental attributes, as well as the quality of the environment is an important factor affecting overall quality of life.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
<p><i>Scottish Executive (1999) National Planning Policy Guidance (NPPG) 14: Natural Heritage</i></p>	<p>This document sets out the Government's objectives with regard to Scotland's natural heritage. They aim to conserve, safeguard and, where possible, enhance:</p> <ul style="list-style-type: none"> ▪ The overall populations and natural ranges of native species and the quality and range of wildlife habitats and ecosystems ▪ Geological and physiographical features ▪ The natural beauty and amenity of the countryside and the natural heritage interest of urban areas ▪ Opportunities for enjoying and learning about the natural environment 	<p>The SEA will consider natural heritage and include objectives to conserve and safeguard native species, wildlife habitats, ecosystems, geology and natural beauty and amenity of the countryside.</p>
<p><i>Scottish Executive (1999) National Planning Policy Guidance 18: Planning and the Historic Environment</i></p>	<p>This NPPG deals primarily with Scheduled Monuments, Listed Buildings, Conservation Areas, World Heritage Sites, historic gardens, designated landscapes and their settings.</p> <p>The Guidelines are:</p> <ul style="list-style-type: none"> ▪ Outline national policy on the historic environment which local authorities should consider in formulating and assessing development proposals. ▪ Explains how the protection of the historic environment and the promotion of opportunities for change can contribute to sustainable development. ▪ Identify a range of planning actions designed to achieve conservation objectives, including implications for development plans and development control. ▪ The historic environment can be threatened by inappropriate development. Planning has a role to play in providing a mechanism for the co-ordination and integration of conservation policies and safeguarding historic resources from adverse impacts. 	<p>The SEA should ensure all relevant issues pertaining to the historic environment are addressed and the framework should contain an objective relating to the preservation of the historic environment. Baseline data in relation to strategic heritage features should also be obtained.</p>
<p><i>Scottish Executive (2003) Securing a Renewable Future – Scotland's Renewable Energy</i></p>	<p>This document aims to increase renewable electricity generation in Scotland as a response to climate change. In Programme for Government 2, the Executive set a target of 18% of electricity generation in Scotland from renewables by 2010. It also discusses a possible objective of 40% of electricity generated from renewables by 2020.</p>	<p>Sustainability objectives should be included that relate to the consumption of energy and use of low carbon, renewable energy sources.</p>
<p><i>Scottish Executive (2004) Scotland's Biodiversity – It's in your hands</i></p>	<p>This document's vision is for Scotland to be recognised as a world leader in biodiversity conservation by 2030. This incorporates 5 key objectives:</p> <ul style="list-style-type: none"> ▪ Species & Habitats: To halt the loss of biodiversity and continue to reverse previous losses through targeted action for species and habitats ▪ People: To increase awareness, understanding and enjoyment of biodiversity, and engage many more people in conservation and enhancement ▪ Landscapes & Ecosystems: To restore and enhance biodiversity in all our urban, rural and marine environments through better planning, design and practice ▪ Integration & Co-ordination: To develop an effective management framework that ensures biodiversity is taken into account in all decision making ▪ Knowledge: To ensure that the best new and existing knowledge on biodiversity is available to all policy makers and practitioners. 	<p>The SEA framework should contain objectives that facilitate the consideration of effects from a GDF in relation to the protection and conservation of biodiversity.</p>
<p><i>Scottish Executive (2004) SPP7: Planning and Flooding</i></p>	<p>The principles of the document are:</p> <ul style="list-style-type: none"> ▪ Developers and planning authorities must consider the possibility of flooding from all sources. ▪ New development should be free from significant flood risk from any source. 	<p>The SEA needs to include objectives relating to flood risk and the need to manage runoff effectively. The baseline data collation</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<ul style="list-style-type: none"> ▪ New development should not materially increase flood risk elsewhere, add to the area of land requiring flood protection measures, affect the ability of the functional floodplain to attenuate the effects of flooding by storing water, interfere detrimentally with the flow of water in the floodplain and compromise options for future shoreline or river management. ▪ Flooding from sources other than watercourses on the coast must be considered where new development is proposed. 	<p>process should gather information in relation to the location of coastal and fluvial flood risk areas.</p>
<p><i>Scottish Executive (2005) Building a Better Scotland: Infrastructure Investment Plan – Investing in the Future of Scotland</i></p>	<p>This Strategy intends to ensure that the nation's infrastructure is improved; that public services are modernised; that investment planning takes a long-term view; that the allocation of resources is linked to the achievement of objectives and targets; and that the public sector disposes of surplus assets. The objectives of the Plan are to:</p> <ul style="list-style-type: none"> ▪ Improve the efficiency of how services are being delivered ▪ Improve the standard of our infrastructure, such as our transport network and school building estate ▪ Improve the business environment, promoting research and development and enabling employment and training opportunities for Scotland's workforce ▪ Improve the co-ordination of our infrastructure investment by geographical area and between portfolios in order to secure extra value from our existing investment and infrastructure programmes ▪ Improve the co-ordination with the private sector and secure a mixed economy and mixed tenure of investment. 	<p>The SEA needs to include objectives that will act in conjunction with the Plan and assist in achieving its objectives.</p>
<p><i>Scottish Executive (2005) Choosing Our Future – Scotland's Sustainable Development Strategy</i></p>	<p>This Strategy sets out the measures that the Scottish Executive will take in Scotland to turn the UK shared framework for sustainable development into action.</p> <p>The vision is for a Scotland that :</p> <ul style="list-style-type: none"> ▪ Is a leader in green enterprise ▪ Has transformed its approach to waste, reducing our dependency on landfill. ▪ Is maximising the potential of our renewable energy sources ▪ Has a vibrant, low-carbon economy ▪ Provides a quality environment for all. <p>Key objectives include:</p> <ul style="list-style-type: none"> ▪ Economic growth is the top priority – but not at any cost. ▪ Smarter use of resources is essential. ▪ Reducing the need to travel. 	<p>The SEA needs to consider how the aims of the sustainable development Strategy can be used to form an integral part of the SEA methodology. Sustainability objectives should be developed that cover sustainable resource use, reducing the need to travel, creating an environment that provides the conditions for health and well-being, protecting biodiversity and reducing greenhouse gas emissions.</p>
<p><i>Scottish Executive (2005) One future – different paths – The UK's shared framework for sustainable development</i></p>	<p>This Strategy sets out the measures that the Scottish Executive will take in Scotland to turn the UK shared framework for sustainable development into action. The vision is for a Scotland that:</p> <ul style="list-style-type: none"> ▪ Is a leader in green enterprise ▪ Has transformed its approach to waste, reducing our dependency on landfill ▪ Is maximising the potential of our renewable energy sources and has a vibrant, low-carbon economy ▪ Provides a quality environment for all. <p>Key outcomes include:</p> <ul style="list-style-type: none"> ▪ Economic growth is the top priority – but not at any cost ▪ Smarter use of resources is essential ▪ Reducing the need to travel ▪ Encouraging travel by more sustainable modes 	<p>The SEA needs to consider how the aims of the sustainable development Strategy can be used to form an integral part of the SEA methodology. Sustainability objectives should be developed that cover sustainable resource use, reducing the need to travel, creating an environment that provides the conditions for health and well-being, protecting biodiversity and reducing emissions.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<ul style="list-style-type: none"> ▪ Support initiatives to promote more efficient freight practices ▪ Investment in rail infrastructure ▪ Increased economic opportunities for all ▪ An environment that provides the conditions for health and well-being ▪ A focus on the promotion of good mental health and well-being ▪ Regeneration of local environments ▪ Putting people at the heart of change ▪ Moving away from over-dependence on landfill ▪ Pursuing improvements in transport to tackle growth in road traffic, reduce congestion and improve air quality ▪ Tackling problems on the ground leading to improvements in the local environment, personal wellbeing and safer communities ▪ Halt biodiversity loss ▪ Manage natural resources sustainably ▪ Protect the environment effectively, on the basis of evidence and using the best available science ▪ Reduce greenhouse gas emissions ▪ Reduce ecological impact. 	
<p><i>Scottish Executive (2005)</i> <i>Scotland's Renewable Energy Potential – Realising the 2020 Target</i></p>	<p>This document discusses how and the likelihood of meeting Scotland's 2020 target of generating 40% of its electricity from renewable sources by 2020. This finds that an additional 3.4GW of capacity needs to be built. This target is an ambitious target as a response to UK-wide renewable energy targets.</p>	<p>Sustainability objectives should be included that relate to the consumption of energy and use of low carbon, renewable energy sources.</p>
<p><i>Scottish Executive (2006)</i> <i>Changing Our Ways – Scotland's Climate Change Programme</i></p>	<p>This document details a review of the Scottish Executive's strategic approach towards tackling climate change. It is intended to strengthen this approach and step-up the Executive's efforts to transform Scotland into a technologically advanced and sustainable low-carbon economy. The key objective is to strive to make Scotland the best small country in the world at tackling issues such as climate change. Scotland's response to climate change will be characterised by the following:</p> <ul style="list-style-type: none"> ▪ Developing a transparent, open and inclusive process ▪ Integrating climate change routinely into policy development across all sectors and at all levels ▪ Achieving Scotland's contribution in the most sustainable way ▪ Influencing and contributing to UK, European, and global efforts to respond and adapt to climate change where Scotland's participation can add most to the process. ▪ This document sets for the first time the Scottish Share of the UK Kyoto Protocol targets which roughly equates to 1.7MtC in annual savings by 2010. The Scottish Executive's target is to exceed the Scottish share by 1million tonnes of carbon by 2010. ▪ The Scottish Executive has set a target to generate 18% of Scotland's electricity from renewable source by 2010 and 40% of electricity from renewable sources by 2020. 	<p>The Sustainability objectives will ensure that appropriate consideration is given in the assessment to sustainable methods of transport and access and minimal disruption to the existing strategic transport infrastructure.</p>
<p><i>Scottish Executive (2006)</i> <i>People and Place – Regeneration Policy Statement</i></p>	<p>The document focuses on the transformation of places for the better. The transformation will be seen in a range of outcomes including:</p> <ul style="list-style-type: none"> ▪ Improved business confidence ▪ Increased economic activity and employment ▪ Higher income and less reliance on benefits ▪ More effective public services ▪ Improved educational outcomes and higher skills base ▪ Higher land and housing values ▪ Improved community confidence 	<p>The SEA needs to include environmental protection objectives covering all the SEA Directive topics and baseline data needs to be collated about the quality of the environment.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
	<ul style="list-style-type: none"> An improved and better designed built environment An enhanced natural environment, including access to greenspace. 	
<p><i>Scottish Executive and Scottish Environment Protection Agency (2003) National Waste Plan</i></p>	<p>The national waste plan forms the keystone in the implementation of the national waste Strategy. It outlines the Scottish Executive's policies for sustainable waste management to 2020. The aims of the Plan are to minimise the impact of waste on the environment, both locally and globally, to improve resource use efficiency in Scotland, and to remedy the environmental injustices suffered by those who have to live with the consequences of a wasteful society.</p>	<p>The SEA should consider the management of radioactive waste.</p>
<p><i>Scottish Natural Heritage (2002) Natural Heritage Futures</i></p>	<p>This initiative promotes the better management of natural heritage. The intention is to guide the future management of the natural heritage towards 2025, within the wider context of sustainable development. The landscapes and wildlife and highly valued assets and have been shaped by human activity. Under sensitive management, the natural heritage also has the potential to enhance people's lives and provide economic benefits.</p>	<p>The SEA should include objectives which seek to protect natural heritage and baseline data should be collated about the existing conditions.</p>
<p><i>Welsh Assembly Government (2000) Wales' Changing Climate, Challenging Choices – The impacts of climate change in Wales from now to 2080</i></p>	<p>The document identifies the potential impacts of climate change in Wales over the next 100 years.</p> <p>The report identifies the potential consequences of climate change for a range of topic areas including: flood defence and coastal protection; ecology; the historic environment; health, the economy; agriculture and forestry; transport, energy; manufacturing; water resources; tourism and recreation.</p>	<p>The SEA should include an objective relating to the reduction of greenhouse gas emissions. The SEA should also gather baseline data in relation to risks associated with climate change like flood risk and coastal inundation.</p>
<p><i>Welsh Assembly Government (2002) Wise about Waste – The National Waste Strategy for Wales</i></p>	<p>The primary objectives of the waste Strategy are two-fold:</p> <ul style="list-style-type: none"> To make Wales a model for sustainable waste management by adopting and implementing a sustainable, integrated approach to waste production, management and regulation (including litter and flytipping) which minimises the production of waste and its impact on the environment, maximises the use of unavoidable waste as a resource, and minimises where practicable, the use of energy from waste and landfill To comply with the requirements of relevant EC waste Directives and UK legislation. <p>The main targets in relation to hazardous waste is:</p> <ul style="list-style-type: none"> By 2010, to reduce the amount of industrial and commercial waste going to landfill to less than 80% of that landfilled in 1998 By 2010 reduce the amount of hazardous waste generated by at least 20% compared with 2000. 	<p>The SEA should consider the management of radioactive waste.</p>
<p><i>Welsh Assembly Government (2004) People, Places, Futures: The Wales Spatial Plan</i></p>	<p>The plan is a 20 year plan for the sustainable development of Wales. It is based around a selection of key themes:</p> <ul style="list-style-type: none"> Building Sustainable Communities Promoting a Sustainable Economy Valuing the Environment Achieving Sustainable Accessibility Respecting Distinctiveness Working with our Immediate Neighbours. 	<p>The Sustainability objectives will ensure that appropriate consideration is given to all principles of sustainable development such as the key themes outlined.</p>



Plan, programme or strategy	Objectives and targets identified in the document	Links to the SEA
<p><i>Welsh Assembly Government (2006) Environment Strategy for Wales</i></p>	<p>The Environment Strategy and supporting Action Plan, which details specific actions, aims to deliver the vision and outcomes set in the Strategy on the priority areas for the environment in Wales. The ecological footprint of Wales is identified and it sets out the key pressures on the environment. The key challenges are:</p> <ul style="list-style-type: none"> ▪ Climate change. ▪ Managing the land and sea. ▪ The sustainable use of ecosystems and natural resources ▪ Identifying the pressures on biodiversity and halting the decline in biodiversity ▪ Achieving a high quality of life ▪ The need to reform the public sector to ensure the right structures are in place to deliver our environmental objectives. <p>The key target in this Strategy is to reduce greenhouse gas emissions by 20% by 2010 and by 60% by 2050.</p>	<p>The SEA should include objectives that complement the objectives and targets of this Strategy, for example protecting biodiversity, cultural heritage and promoting a good quality of life for all.</p>
<p><i>Welsh Assembly Government (2008) People, Places, Futures: The Wales Spatial Plan (2008 Update Consultation)</i></p>	<p>This document is an update of the 20 year remit outlined in the 2004 Spatial Plan for the sustainable development of Wales. It is based around a selection of key themes:</p> <ul style="list-style-type: none"> ▪ Building Sustainable Communities ▪ Promoting a Sustainable Economy ▪ Valuing the Environment ▪ Achieving Sustainable Accessibility ▪ Respecting Distinctiveness ▪ Working with our Immediate Neighbours. 	<p>The Sustainability objectives will ensure that appropriate consideration is given to all principles of sustainable development such as the key themes outlined.</p>
<p><i>Welsh Assembly Government, Scottish Executive, Defra and DoENI (2007) Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom</i></p>	<p>The policy statement covers all aspects of the generation, management and regulation of solid Low Level Waste (LLW) and applies to the following organisations: those responsible for the production and management of wastes (waste producers and managers); the Nuclear Decommissioning Authority; the regulatory bodies; the Food Standards Agency; waste disposal facility operators; and regional planning bodies; and planning authorities.</p>	<p>The Sustainability objectives should include reference and consideration of the protection of environmental resources from radioactive waste discharges in the decommissioning process.</p>
<p><i>Welsh Assembly Government, BERR, Defra, DoENI (2008) Managing Radioactive Waste Safely - A Framework for Implementing Geological Disposal</i></p>	<p>This document essentially outlines the process that will be followed when developing a geological disposal facility, provides estimates of volumes of waste that are likely to need to be managed and provides a broad indication of how a geological disposal facility would be designed and how the MRWS process will develop in the future. This was a consultation document that sought views on all of the issues. The document stated that the geological disposal facility programme will fully assess and account for environmental and sustainability issues through the application of SEA, SA and EIA.</p>	<p>The Sustainability objectives will ensure that appropriate consideration is given to how waste is disposed of and the safety in decommissioning plants.</p>
Other Particularly Relevant Plans, Programmes or Strategies		
<p><i>EA (2009) Water for Life and Livelihoods - River Basin Management Plan; Scottish Environment Protection Agency (2008) Draft River Basin Management Plan for the Scottish River Basin</i></p>	<p>These documents are required under the Water Framework Directive. They highlight the quality of water and groundwater within each river basin district and highlight the strategic management of water resources for the future and to meet the water quality targets set out in the Water Framework Directive. It is not considered appropriate to review each plan separately at this stage as the specific location of a GDF facility is unknown. However, it is considered relevant to note them and ensure that the SEA provides consideration to relevant water issues.</p>	<p>The sustainability objectives will ensure that appropriate consideration is given to potential effects of a GDF on water.</p>



Appendix C

Baseline evidence

Table C1 provides a generic overview of baseline information that can be used to inform and taken into consideration during the assessment of the generic illustrative geological disposal concepts. More detailed information will be included as volunteer communities and, at a later stage of the Managing Radioactive Waste Safely (MRWS) programme, specific potential sites are identified.

Table C1 Baseline evidence

Policies and Planning

DEFINITION: Policies and planning refers to the frameworks within which a Geological Disposal Facility (GDF) would have to operate (and acquire relevant permissions to undertake activities).

NATIONAL BASELINE CONTEXT:

A list of relevant plans and programmes is highlighted in **Appendix B**.

Landscape and Visual

DEFINITION: Landscape is considered to be the hierarchy of the different components that interact to form a landscape; the elements, characteristics and patterns that interact to form distinct landscape character areas. It also considered the visual amenity of the area.

NATIONAL BASELINE CONTEXT:

There are 14 National Parks within the UK. Many of the UK's nuclear facilities are situated in relatively rural locations. The general scale of the buildings associated with a number of the Nuclear Decommissioning Authority's (NDA's) sites has a relatively significant effect on the landscape and are, as such, relatively noticeable features. It is proposed that as part of decommissioning, many sites may store radioactive waste in temporary structures on-site, until such time as an appropriate national disposal route is identified. These interim structures may affect the visual element of the landscape around some sites.

A number of NDA sites are located within, or in close proximity, to designated landscape areas, such as National Park, Area of Outstanding Natural Beauty (AONB) and Heritage Coasts.

Cultural Heritage

DEFINITION: Cultural heritage refers to historic elements of an area that contribute to a sense of place and cultural identity. It is represented by a wide range of features, both above and below ground, which result from past human use of the landscape. These include standing buildings, many still in use, subsurface archaeological remains and artefact scatters. It also includes earthwork monuments as well as landscape features such as field boundaries and industrial elements, from prehistoric to modern times.

NATIONAL BASELINE CONTEXT:

The UK has a rich historic environment reflecting thousands of years of human occupation, settlements and activities. The most important features are designated for protection as Scheduled Ancient Monuments (SAM), Listed Buildings, Register of Parks and Gardens and the Register of Historic Battlefields. Sites are designated by the relevant authority (English Heritage, Cadw, and Historic Scotland). In England, there are over 19,200 SAMs, 1,600 registered parks and gardens and nearly 373,900 listed buildings. In Scotland there are some 8,000 SAMs and some 47,000 listed buildings.



Geology and Soils

DEFINITION: This topic considers the baseline relating to the geology and soils. It considers contamination of the ground by both radiological and non-radiological sources where relevant.

Geology and Soils

NATIONAL BASELINE CONTEXT:

Radioactive Contamination

The majority of NDA sites have some amount of ground or groundwater contaminated with radioactive substances varying from a few tens of cubic metres of contamination to millions of cubic metres.

Typical sources of radioactive contamination in ground and groundwater across the NDA estate are:

- Effluent drains and treatment plants;
- Waste disposal / storage areas;
- Decontamination facilities; and, at the reactor sites; and
- Cooling ponds and pond water pipelines.

Non Radiological Contamination

The UK has a substantial legacy of chemical contaminants in soil. Sometimes the contaminants may be present naturally, whilst frequently, they occur as a result of human industrial and domestic pollution.

Typical sources of non-radioactive / chemical contamination in ground and groundwater across the NDA estate are associated with:

- Storage, transfer and use of hydrocarbon fuel;
- Engineering works, including the use of industrial solvents typically for cleaning; and
- Waste facilities including waste storage, disposal and incineration.

Geology

Geology of particular importance is protected through designation as a Regionally Important Geological Site (RIGS) or geological Sites of Special Scientific Interest (SSSI). Within England there are some 1,200 geological SSSIs. In Wales, the Isle of Anglesey is currently preparing an application to become a member of the European Geopark Network and UNESCO Global Geoparks although it is not yet a Geopark.

Water

DEFINITION: This topic refers to the quality of surface water resources including lakes, rivers and marine waterbodies. It also highlights the radiological exposure and dose to the critical group as a result of discharges from sites. Furthermore, the topic considers the consumption of water resources.

NATIONAL BASELINE CONTEXT:

Radioactive Discharges

Radioactive discharges to waters from the NDA sites are regulated by the applicable environment agencies. Specific authorisations are required from the relevant environment agencies before discharges can take place. These authorisations contain limits of the quantities of radioactive materials that can be discharged. These limits are set conservatively to provide protection to people and the environment.

The public dose limit for radiological discharges to the aquatic environment is set at 1 mSv/y. The dose rates associated with current liquid discharges from NDA sites are significantly lower than the public dose limit for all sites.

Authorisation limits are set such that if discharges were to occur at the discharge limit, this would not pose a significant risk to the integrity of protected nature conservation areas of national and international importance.



Non Radioactive Issues

Liquid non radioactive discharges from the NDA's sites include nitrate discharges from Springfields and Sellafield. Non radioactive discharges from most NDA sites are limited to drainage discharges and discharges from site sewage treatment plants.

Water

Other than the grout plant described under Air Quality (below), the only non radioactive discharges from the Low Level Waste (LLW) Repository are trace radioactive contaminants within the leachate described above, again mostly originating from the original trench disposals.

Where sites are located close to rivers or other terrestrial or marine water bodies, and water quality is monitored, the results indicate that water quality meets relevant UK and EU legislative targets.

Water Consumption

In 2007/08, the UK consumed approximately 16,000 megalitres per day, the majority of which was household consumption. This is a relatively consistent trend throughout the decade, although there has been a continued reduction in consumption since a peak in 2003/04.

Most of the NDA sites consume relatively large quantities of water. In 2007 (excluding Chapelcross, Hunterston A or Dounreay, for which data was not available), NDA sites consumed some 2.85 million m³ of water in 2007 (excluding cooling water, which is returned to source). Significantly larger volumes of cooling water are used at operational generating power station sites.

Flood Risk

It is estimated that some 13,000 ha of England are potentially at risk (not taking into account existing flood defences).

Biodiversity

DEFINITION: This topic refers to the range of wildlife (fauna, excluding humans) and vegetation (flora), and the supporting habitats that contribute to the ecological biodiversity of an area. Of particular note are valued ecological receptors such as designated sites and protected species. This topic does not include the impact of radioactive and non radioactive discharges on flora and fauna (covered in Air Quality and Surface Water Quality and Resources).

NATIONAL BASELINE CONTEXT:

Designated Sites

There are over 4,000 SSSI covering some 7% of the land area in England, more than 1,000 in Wales covering some 12% of the land area and more than 1,400 in Scotland, covering nearly 13% of Scotland's land area. There are also 608 Special Areas of Conservation (SAC) in the UK covering some 10% of the UK's land area. An additional 10 candidate SAC are also located within the UK. Furthermore, there are 256 designated Special Protection Areas (SPA) in the UK covering approximately 6.7% of the UK land area, and 146 Ramsar sites covering approximately 3% of the UK land area (Source: www.jncc.gov.uk). The UK contains many protected species of international importance. Due to the generic level of assessment, it is not appropriate to attempt to identify the effects of extent of all such species. Subsequent assessments will identify ecological receptors in more detail as appropriate.

Traffic and Transport

DEFINITION: Traffic and transport refers to the transport and travel activities around NDA sites and in particular the proportion of this relating to the management of LLW. This section includes the implications of transport activity on local communities in terms of volumes of activity on the road network.

NATIONAL BASELINE CONTEXT:

Overview

The UK has an established road and rail infrastructure with annual road freight totalling 150 billion tonne kilometres and rail freight totalling 50 billion tonne kilometres. The volume of motor vehicle traffic in the UK increased by 8.41% between 2000 and 2006 and congestion in towns and cities, and on some parts of the strategic road network, is an ever increasing issue of importance (Source: www.dft.gov.uk). Half a million packages of radioactive materials are shipped within the UK each year. Transport of radioactive materials is associated with a number of activities and industries, for example electricity generation, healthcare, university research and education, with the nuclear industry making up only a small proportion of these movements. Despite this, transport is seen as a key issue for local stakeholders in the context of decisions about the management of wastes from nuclear sites.



Traffic and Transport

This local concern is usually focussed on two key issues:

- Disturbance to local communities as a result of transport
- The safety of radioactive materials during transport

Safety of Radioactive Substance Transport

The safety of radioactive substance transport is an important area of stakeholder interest. In addition, there is the potential for social amplification of risk to result in perceived risks from LLW transport appearing to be more significant than an objective assessment would suggest.

The transport of radioactive material is governed by UK Transport legislation, which is derived from International Standards. This sets out the minimum requirements for the specification of containers and additional measures required to ensure the risk of transporting radioactive materials is minimised. These requirements and the subsequent controls in place to ensure the safety of radioactive materials in transport reduce the risks from such transport to a low level. In addition, the levels of radioactivity within consignments of LLW are relatively low when compared to other radioactive waste transports (e.g. spent fuel and surplus sources), reducing the overall risk further.

Conventional road safety is an important national issue (every year around 3,500 people are killed on Britain's roads and 40,000 are seriously injured). However, given the relatively small number of LLW transports, when compared to other transport around nuclear sites or compared to non radioactive waste management, the conventional safety record of the nuclear industry suggests LLW transport is likely to have a negligible effect on overall road safety risk.

Air Quality

DEFINITION: This topic considers the evidence base for air quality, which may be affected by a GDF. It contains information relating to the emission of pollutants and particulate matter, as well as radioactive discharges to the atmosphere.

NATIONAL BASELINE CONTEXT:

Radioactive Emissions

Discharges of radioactivity to the air from the NDA sites are regulated by the relevant environment agencies (Environment Agency (EA), EA Wales, Scottish Environment Protection Agency (SEPA) and Department of Environment Northern Ireland (DoENI)). Specific authorisations are required from the relevant environment agency before discharges can take place. These authorisations contain limits on the quantities and type of radioactive material which can be discharged. These limits are set conservatively so that if discharges were to occur at the discharge limit, they would not pose a significant risk to human health or to the integrity of protected conservation areas of national and international importance.

Activities at NDA sites result in emissions of a range of radionuclides. Discharges generally occur from ventilation air from process plants handling fuel reprocessing, the treatment of wastes (such as incineration) and the gaseous decay from radioactive waste stored or disposed of, and ventilation air from contaminated redundant facilities undergoing decommissioning or associated materials (Source: *UK Strategy for Radioactive Discharges 2006 – 2030 – Consultation Document*, Defra, et. al., 2008).

Information on the volumes of site-specific radionuclides emitted is included in the *Radioactivity in Food and the Environment Report* (EA, et. al., 2008).

The public dose limit for radiological discharges to atmosphere is 1 mSv/y. The doses associated with current aerial discharges from NDA sites are a small fraction of this public dose limit and well within the relevant dose constraints. Consequently, the impact on public health from radioactive discharges to air is considered to be very small.

Non-Radioactive Emissions

There are no Air Quality Management Areas (AQMAs) near the NDA sites since none of the air quality management objectives have been exceeded. In the UK however, some 227 Local Authorities have declared AQMAs. These are predominantly in urban areas and are generally related to Nitrogen Dioxide (NO₂) and Particulates (PM₁₀) emissions associated with road networks (Source: www.airquality.co.uk/archive).

In 1990 UK emissions of Nitrogen Oxide (NO_x) (as NO₂) were 2.7 Mt. These have reduced to 1.5 Mt in 2007, largely due to abatement measures for road transport and at coal-fired power stations, which continue to account for 54% of emissions.

Sulphur dioxide (SO₂) emissions in the UK have reduced from 3.7 Mt in 1990 to 0.6 Mt in 2007. This is largely due to the decrease in the use of coal and use of increasingly effective abatement technologies. The UK emissions of PM₁₀ have declined by 52% from 0.28 Mt in 1990 to 0.14 Mt in 2007. This reflects the decrease in use of coal power (Source: National Atmospheric Emissions Inventory (NAEI) (2009) *Air Quality Pollutant Inventories for England, Scotland, Wales and Northern Ireland: 1990-2007*, AEA, Didcot).



Climate Change

DEFINITION: This topic considers the contribution of NDA sites to climate change through direct and indirect emissions of greenhouse gases. It also considers energy use on NDA sites as a major contributor to indirect emissions of greenhouse gases. The topic also considers the implications of climate and landscape change on the NDA's sites.

NATIONAL BASELINE CONTEXT:

Greenhouse Gases

In 1990 UK net greenhouse gas emissions were 773.9 Mt carbon dioxide (CO₂) equivalent. In 2007, the UK net emission of CO₂ was 634.7 Mt CO₂ equivalent. Approximately some two thirds of this is accounted for by industry, transport and power sectors (Source: www.decc.gov.uk – UK 5th National Communication under UNFCCC (2009) and www.theccc.org.uk).

In 2007, NDA sites (excluding Chapelcross, Hunterston A or Dounreay for which data was not available) emitted a total of 222,600 tonnes of CO₂ equivalent.

Energy

In 2007, the UK consumed approximately 9.4 million TJ of energy. In that year, NDA sites (excluding Chapelcross, Hunterston A and Dounreay for which data was not available) used approximately 6,800 TJ of energy. Consumption was not uniform, with three sites (Wylfa, Sellafield (including Calder Hall and Windscale) and Springfields) accounting for 88% of the total energy consumption by NDA sites, more than 6,000 TJ. This reflects the nature and extent of their continuing operations on site.

Climate Change

The UK climate projections 2009 (UKCP09) highlight that the UK will become warmer, particularly during summer. The type of precipitation will remain relatively consistent although the volume of precipitation is likely to reduce in summer. By the 2080s, the mean summer temperature is likely to be between 3 and 4°C higher across most of the UK. Mean summer precipitation is likely to reduce by 10% across much of Northern England and Scotland, and by as much as 40% along the south coast of England and much of the Southwest.

Many of the NDA sites are located within close proximity of the coastal zone or flood plains. There are well established controls to protect sites from current external hazards such as flooding and coastal erosion, and these are reviewed periodically. However, if high climate change scenarios are realised, the potential vulnerability of some sites to climate change and the risk of flooding may increase if further mitigation is not provided, although most of these effects are over timescales of decades.

In the very long-term, (thousands of years), coastal erosion is a potential consideration in the planning and design of facilities for the disposal of long lived radioactive wastes. These issues are considered in detail in the regulatory processes which cover radioactive waste disposal.

Noise and Vibration

DEFINITION: Noise and vibration refers to the level of environmental noise and vibrations in the ground resulting from activities on and around NDA sites.

NATIONAL BASELINE CONTEXT:

Noise receptors include schools, residential accommodation and sensitive species of wildlife. As noise is a localised issue and the assessment is generic, non-location specific, noise baseline cannot be identified at this stage.

Land Use

DEFINITION: The baseline for this topic highlights the dominant land uses around the NDA sites as well as the consumption of natural and material assets. It also includes realisation of NDA assets.

NATIONAL BASELINE CONTEXT:

The UK covers 22.6 million hectares (ha). Between 1998 and 2007 the areas of arable and horticultural habitat decreased by some 9 % to 4,608,000 ha. Broadleaved mixed and yew woodland increased by nearly 6% to 1,406,000 ha. Built-up areas and gardens increased by 3.4% to 1,323,000 ha.



Socio-economics

DEFINITION: This topic baseline data addresses part of the social and economic aspects of sustainability. In particular, the contribution that the existing nuclear sites and in particular LLW facilities and waste management make towards supporting the economic prospects in the area, including educational and training opportunities. This section also considers the wider wellbeing implication of such economic and employment issues.

NATIONAL BASELINE CONTEXT:

The UK is the world's sixth largest economy (with a \$2.7 trillion Gross Domestic Product in 2008). The economy grew at an annual average rate of 3% between 1997 and 2007, although there has been a contraction following the effects of the current recession. The working age employment rate fell from 75% to 74% between 2008 and 2009. As of quarter 2 in 2009, there were 1,297,000 people employed in the construction industry.

The creation of the NDA and its focus on decommissioning and clean-up is likely to deliver many opportunities. However, whilst substantial employment is likely to continue for many years, the decommissioning and clean-up of the NDA sites may also have adverse social and economic impact on communities, particularly as job numbers decline.

The NDA's activities may also have a broader potential social and economic impact on local communities, both directly such as the potential for disruption from increased transport movements and increased demand for public services resulting from the periodic employment of a greater number of contractors and indirectly through activities affecting the perception of local communities and feelings of community well-being.

NDA Socioeconomic Policy

The Energy Act 2004 requires the NDA to consider the socio-economic impacts of its activities on local communities. In this respect the Government has charged the NDA with playing a full and active role in helping to mitigate the impact of decommissioning and clean-up and in contributing to the development of sustainable communities living near NDA sites. The lead responsibility for economic development remains with the relevant Regional Development Agencies, Enterprise Networks, Welsh Assembly Government and Local Authorities. The NDA supports these agencies through partnerships, developing proposals and direct funding projects.

The NDA provides socio-economic support through which it aspires to support the development of healthy, diversified local economies as site activities come to an end. The NDA also seeks to reduce over-reliance of communities on the nuclear industry which is achieved through 3 methods:

- Direct NDA funding to support socio-economic activities;
- Support through NDA operations; and
- Funding Site Licensed Companies to deliver local socio-economic support.

In 2007/08, the NDA contributed some £15 million in socio-economic grants, an increase on the £10 million of 2006/07 (Source: NDA (2008) Annual Report and Accounts 2007/08).

More information on the NDA's approach to socio-economic issues is set out in the socio-economic policy (available from www.nda.gov.uk).

Health and Well-being

DEFINITION: The safety and protection of workers and the public is a key priority for the NDA and the operators of NDA sites. This section considers the safety and health of workers and the public, both as a result of industrial accidents and exposure to radioactive and hazardous substances.

Health is however a wider issue than this. It is defined by the World Health Organisation Europe as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. The Nuclear LLW Strategy may potentially affect wider public health, safety and well-being as a result of the management of LLW. However, there are likely to be many aspects of this wide definition of health that are beyond the NDA's direct control and which the strategy will have limited influence over.

NATIONAL BASELINE CONTEXT:

There has been a positive trend over the past two decades of increases in the life expectancy of the population. In 2007, 88% of adults said that they had good or fairly good health. In 2007/08 there were an estimated 10.1 million crimes against adults living in private accommodation in England and Wales, a decline of 48% compared with 1995 levels (Source: Office of National Statistics (ONS): www.ons.gov.uk).



Health and Well-being

According to a review by the Health Protection Agency in 2005, the average dose of ionising radiation exposure of the UK population is approximately 2.7 mSv/y. On average, some 84% of this exposure is due to natural sources of radiations such as radon based geology and cosmic rays. Just 0.1% is on average directly due to radioactive discharges from nuclear and non nuclear sources.

Average sickness absence information for NDA sites is shown in **Figure 1** below. Most sites' performance is below the national average of 8.4 days per employee (10.3 for public sector employees) and in a number of cases is well below these national averages.

Figure 1 2007/08 Sickness Absence Rates at NDA Sites

Site	2007/8 Sickness Absence	2006/7 Sickness Absence	Site	2007/8 Sickness Absence	2006/7 Sickness Absence
Hinkley Pt A	2.50	3.36	Wylfa	7.08	6.12
Low Level Waste Repository	2.90	4.10	Windscale	7.39	8.36
Hunterston A	4.20	4.04	Berkeley	7.40	6.25
Bradwell	4.28	4.05	Springfields	7.82	7.68
Trawsfynydd	4.98	6.15	Sellafield	7.90	7.90
Oldbury	5.19	5.99	Chapelcross	8.01	6.67
Sizewell A	5.66	6.21	Harwell	8.42	6.26
Calder Hall	5.80	6.40	Capenhurst	8.92	6.87
Dungeness A	6.64	5.79	Winfrith	10.74	7.23
Dounreay	7.01	6.79			

In terms of well-being and quality of life, the UK was ranked just outside the top 20 of the UN's Human Development Index in 2009. This was a decrease from 15 in 2005, although there has been a long-term improvement of 0.35% since 1980 (Source: United Nations Human Development Index Reports (accessed at: <http://hdr.undp.org/en/statistics/>)).

Safety

DEFINITION: Safety relates to the safety of workers, including the risk of accidents occurring to employees and hazards on site.

NATIONAL BASELINE CONTEXT:

In 2001/02 there were 251 fatalities across all work sectors, the majority occurring in the construction industry sector (80). In 2001/02, there were over 13,000 incidents causing employees to be incapacitated for more than 3 days (Source: ONS <http://www.statistics.gov.uk/STATBASE/Expodata/Spreadsheets/D3986.csv>).

In terms of road traffic accidents, there were a total of 248,000 casualties on the roads in 2007, a decrease of 4% from 2006. This compares with an annual average of 320,000 between 1994 and 1998. The NDA has developed a method for evaluating safety and environmental hazard to enable the year on year management of hazard reduction and to support the prioritisation of hazard reduction work (more information on this is available on www.nda.gov.uk).



This involves each site identifying the facilities that are of most concern by looking at their radiological and chemical contents, the age and condition of the facility, and the impact on the environment of the facility remaining in its current state.

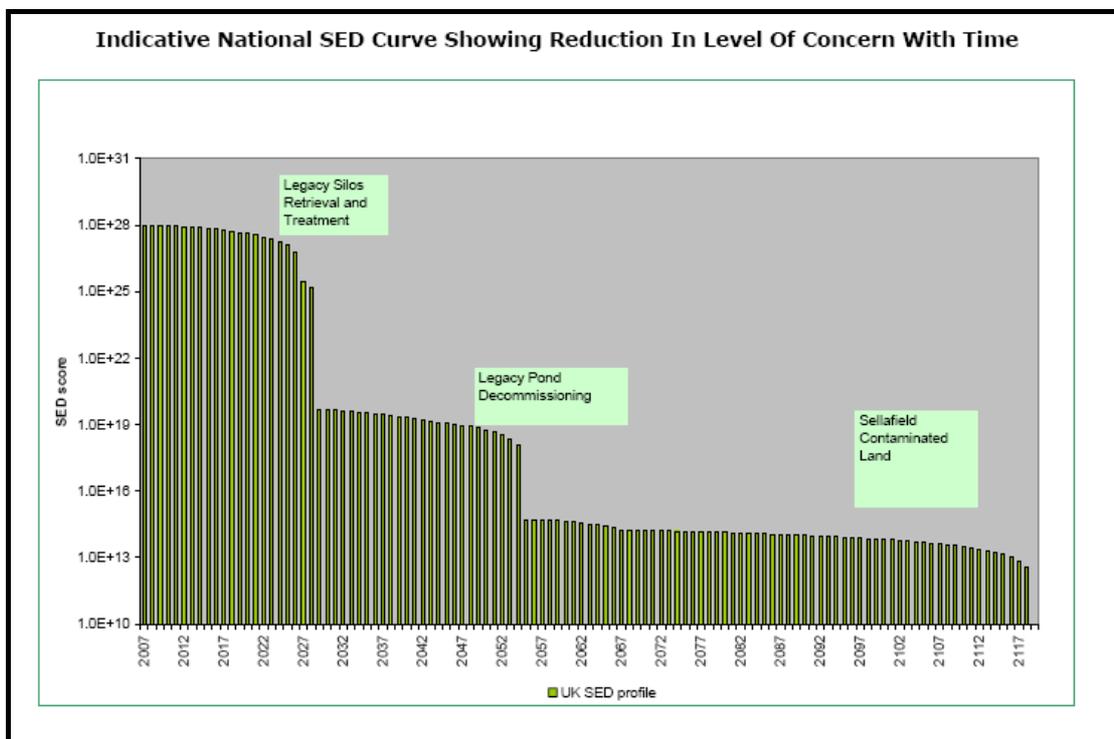
Safety

This exercise results in each facility being given a score, known as the Safety and Environment Detriment (SED) score, which allows the concern associated with the hazards present on each of NDA's sites to be compared on a common scale.

Site plans have also been used to develop a national hazard baseline to enable the year on year management of hazard reduction and to support the prioritisation of hazard reduction work. This shows how the total SED from materials on NDA sites is expected to change over time as legacy wastes and hazardous substances are retrieved and processed or disposed of.

The safety and environmental detriment (SED) of sites is anticipated to decline over time highlighted in the **Figure 2** below.

Figure 2



Waste

DEFINITION: This topic refers to the generation, management, treatment and disposal of radioactive and non radioactive waste on NDA sites and from nuclear sites throughout the UK.

NATIONAL BASELINE CONTEXT:

Overview

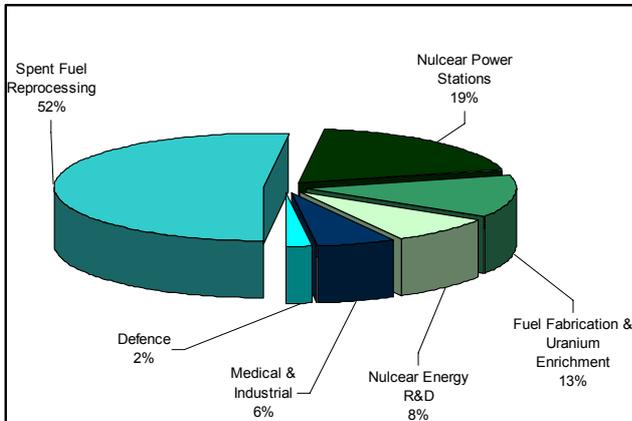
The total predicted volume of radioactive waste from all sources in the UK is estimated at around 3 million m³ (Source: NDA (2008) *The 2007 UK Radioactive Waste Inventory*).

Figure 3 highlights the relevant contribution from various source sectors to this total volume.



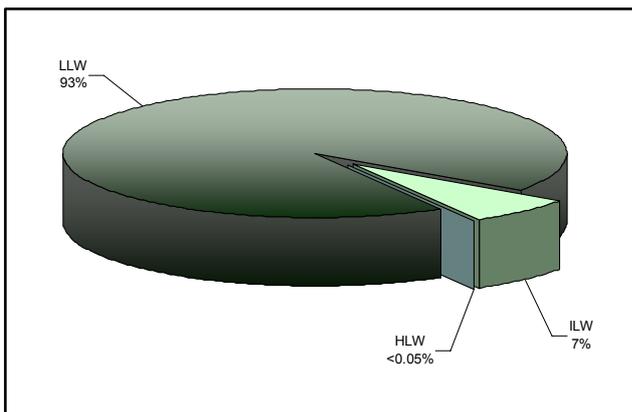
Waste

Figure 3



(Source: NDA (2008) *The 2007 UK Radioactive Waste Inventory*)

Figure 4



Radioactive waste is generally identified by the level of radioactivity of the material, LLW, Intermediate Level Waste (ILW) and High Level Waste (HLW). The majority of waste in terms of volume is LLW, as shown in **Figure 3**.

It is estimated that there is around 3 million m³ of raw unconditioned, unpackaged LLW (of which approximately 1.8 million m³ of all raw LLW is classified as Vitrified LLW).

High Level Waste

HLW is waste in which the temperature may rise significantly as a result its radioactivity, and needs to be taken into account during the design of waste storage or disposal facilities. Largely, HLW comprises nitric acid solutions containing the waste products of reprocessing spent nuclear fuels. The Nuclear LLW Strategy does not have any influence on HLW so further information is not provided in this baseline on HLW. However, the revised NDA Strategy will relate to HLW, and thus further information will be provided then.

Intermediate Level Waste

These are wastes exceeding the upper boundaries for LLW that do not generate sufficient heat for this to be taken into account in the design of waste storage or disposal facilities. The major components of ILW are metal items such as nuclear fuel casing and nuclear reactor components, graphite from reactor cores and sludges from the treatment of radioactive liquid effluents. ILW is typically packaged for disposal by encapsulating it in cement in highly-engineered 500 litre stainless steel drums or in higher capacity steel or concrete boxes.

All ILW has been stored since it was created, except for a small amount disposed of at sea before 1983. It is possible for some ILW wastes to be decontaminated or (in the case of short lived ILW) stored until their radioactivity naturally decays so that they fall below the upper threshold of LLW. Thus while ILW management is generally not within the scope of the Nuclear LLW Strategy, there is a relationship between ILW management and the volume of higher activity LLW requiring long-term management.

Resource Use, Utilities and Services

DEFINITION: This topic focuses on the efficient use of materials and resources.

NATIONAL BASELINE CONTEXT:

In 2003, steel and iron manufacture accounted for £1,131 million of the UK's Gross Value Added (GVA). Cement, lime and plaster accounted for £484 million and construction accounted for £60,891 million. In 2003, the total UK GVA was £981,732 million.



Appendix D Detailed assessment



Appraisal of the surface-based site investigation phase

For the purposes of the assessment of the surface-based site investigation phase it has been assumed that the work for each illustrative geological disposal concept (for higher strength, lower strength sedimentary rock and evaporite rock) would comprise regional surveys, deep borehole construction, post-completion testing and baseline monitoring. A summary of the surface-based site investigation works is detailed below. The total duration of the works is assumed to be approximately 10 years (substantial overlap of consecutive stages is anticipated).

Although the scope of the surface-based site investigations would be broadly similar for each of the three host rock types, there may be differences in implementation, as follows:

- For the higher strength rock type, if the host rock extends to surface it may be appropriate to use relatively small mobile drilling rigs as such boreholes can be drilled at a relatively small diameter with less steel casing required. Compared with the larger drilling rigs which would be required for the other host rock types, such small rigs require fewer drilling crew, a smaller footprint, less supporting infrastructure and can be operated during daylight hours (compared with 24/7 working for larger drilling rigs). As such there is the potential for reduced environmental impacts when using such equipment. This assessment, however, considers the potential impacts associated with the larger type of drilling rig as it is assumed that the host rock does not outcrop at the surface.
- Surface-based site investigations for lower strength sedimentary rock, by nature of their relatively homogeneous nature (uniform in structure and composition), may require fewer deep boreholes to be constructed (in comparison to surface-based site investigations for higher strength rock), with a greater reliance on geophysical surveys. As such there is the potential for reduced local impacts by nature of the reduced number of borehole locations.

Regional surveys:

Regional surveys are assumed to take place over a 1 year period and could involve:

- Preliminary airborne and satellite surveys at a district level (approximately 600km²) to acquire aerial photography, LIDAR surveys, thermal infrared and satellite imagery. This would involve flying a series of low level (at an altitude of approximately 50-150m) parallel traverses (approximately 50-150m apart).
- Second phase airborne surveys to acquire low frequency, radiometric, magnetic and electromagnetic datasets.
- Ground based geophysical surveys at a district level, comprising 2D seismic reflection/gravity surveys along a series of discrete survey lines.
- Other ground based geophysical surveys at a district level to acquire gravity, electromagnetic and magnetic data, undertaken using hand-held portable devices which collect data using non-intrusive techniques.



- Surface mapping at a district level to describe geology, geomorphology and hydrogeology, involving the establishment of meteorological monitoring stations; stream/river gauges (stilling wells); monitoring of existing boreholes; and sampling and analysis of surface and groundwater samples.
- Additional targeted geophysical surveys to provide specific information on superficial strata. This is likely to include 2D seismic refraction, resistivity imaging, electromagnetic and ground penetrating radar.

Deep borehole construction:

Deep borehole construction is assumed to take place over an 8 year period and is assumed to involve the construction of up to 20 deep boreholes (>1,000m), drilled over three phases at each of the candidate sites (occupying approximately 50km² each). A summary of the works associated with deep borehole construction is anticipated to be as follows:

- At each site selected for surface-based investigations, prior to drilling a drilling pad must be prepared at each borehole location. Each drilling pad is expected to comprise an area of 50-100m x 50-100m. The construction of each pad would involve: preparation (levelling and drainage) and soil storage (earthworks); installation of an impermeable membrane, drains, interceptors and possibly a settlement lagoon; placement of working surface (typically graded stone but sometimes concrete); and construction of access tracks (capable of supporting Heavy Goods Vehicles (HGVs)). The provision of cabling (fibre optic, telephone and electric) may also be part of the drilling pad construction. Activities associated with the construction of the drilling pads are anticipated to take place during weekday daylight hours. It is assumed that up to 3 drilling pads could be potentially within 1km of each other.
- A central office compound would be required on site during the drilling campaigns, able to accommodate 100-150 people. It is anticipated that the compound would comprise: offices; warehousing for sample storage (particularly the borehole cores); limited analytical laboratory facilities; changing and messing facilities; welfare facilities; and car parking. It is assumed that the central office compound would operate a 5 day normal working week.
- The boreholes would be constructed using a temporary drill rig, requiring a number of HGVs to transport the rig and necessary ancillary equipment between borehole locations. To provide service to the drilling rig, it is also likely that a mobile crane and forklift(s) would be required on an almost full time basis at each location. Throughout the duration of each borehole construction, estimated to be approximately 6 months, there would be a number of HGV movements to the drill site, typically 5-10 per borehole location per week.
- The work that is likely to be undertaken as part of each borehole construction includes: full core recovery followed by widening using open hold techniques; casing installation; geophysical (wireline) logging; hydrogeological testing; groundwater sampling; in-situ stress tests; and groundwater pressure monitoring.
- A main drilling crew of between 5 and 10 staff would be required throughout the construction and testing of each borehole, supplemented by specialist staff (3 to 4 persons) to undertake activities such



as running casing, geophysical logging, water sampling, testing and equipment installation on a sporadic basis. As drilling activities would continue on a 24-hour basis, 7 days a week, and drill crews are likely to work on an equal time basis, 4 separate crews are required to keep each drill rig fully operational.

- Upon completion of each borehole and subsequent testing, the majority of borehole locations would be reinstated to their previous condition with a small fenced compound constructed around each wellhead and vehicular access maintained, to permit subsequent regular visits for the long-term (during testing and baseline) monitoring. A small number of boreholes may be subject to more detailed post-completion testing such as long duration pumping tests, requiring that the drilling pad is maintained.
- The first phase of the deep borehole drilling campaign is expected to result in the drilling of 7 deep boreholes at each candidate site over a 1 year period.
- The second phase would involve the drilling of a further 7 deep boreholes at each candidate site over a three year period. Other activities which would be occurring during the second phase include:
 - A local scale 3D seismic survey to investigate the detailed structure of the geology in the potential geological disposal facility target location:
 - Surveys to evaluate the near-surface geological conditions including: ground based geophysical surveys; construction of up to 50 shallow (<100 m) boreholes, with a limited amount of hydrogeological testing; geophysical (wireline) logging; and trial pitting and trenching. The shallow boreholes would require the use of mobile (probably truck mounted) drilling rigs and it is unlikely that there would be the need for an engineered drilling platform although dependant on location, an access route may be required. Typically a 3-4 man crew is required at each drilling location.
 - A series of seismic monitoring stations may also be established across the region, each comprising a small fenced compound with a small sheltered monitoring station.
- The third and final phase of deep borehole drilling would involve the drilling of a further 6 deep boreholes. Further shallow investigations would also be undertaken to provide geotechnical information for the design of surfaced based facilities.
- Upon completion of each borehole and subsequent testing, the majority of borehole locations would be reinstated to their previous condition with a small fenced compound constructed around each wellhead and vehicular access maintained, to permit subsequent regular visits for the long-term (during testing and baseline) monitoring. A small number of boreholes, perhaps two to four, may be subject to more detailed post-completion testing (refer to post-completion testing below), which would require that the relatively large drilling pad area is maintained for an extended period to allow such testing to be undertaken.

Post-completion testing:

- A period of post-completion testing over a four year period utilising the completed network of deep boreholes, to address any significant remaining uncertainties would be undertaken. The scope of such



testing could include the following activities: single and cross hole geophysical tomography (seismic, resistivity); single borehole hydrogeological testing (fracture network, short interval); cross hole hydrogeological testing (pairs of boreholes); and large scale pumping tests, involving the removal of water from a borehole to analyse groundwater resources (networks of boreholes).

- Such testing would involve the installation of equipment into boreholes using either small drilling rigs, cranes or work-over units, together with a certain amount of surface equipment to control the tests, including skid mounted units, diesel generators, data acquisition units and discharge pipelines. The above ground equipment would require a certain amount of space, although it is envisaged that this would be easily accommodated within the existing drilling pad.

Baseline monitoring (the final stage of the investigations):

- Following the completion of all active testing (i.e. testing that induces changes to the groundwater system) the groundwater system would be allowed to recover and would be passively monitored for a period of two years to establish baseline conditions.



Table D2 Appraisal of the surface-based site investigation phase

1. Policies and Planning	
A. Higher Strength Rock	
<p>Assessment of Effects:</p> <p>The surface-based site investigations would help to ensure the selection of an appropriate site for the development of a Geological Disposal Facility (GDF), thus contributing positively towards fulfilling international and national policy and legislative commitments for the safe long-term management of radioactive wastes.</p> <p>Regional surveys: The activities involved in this stage should be undertaken in accordance with all national legislation (e.g. handling and use of explosives).</p> <p>Deep borehole construction: The surface-based investigations should comply with a number of national planning policies, including Planning Policy Statement (PPS)1 (Delivering Sustainable Development) and PPS10 (Planning for Sustainable Waste Management) and by contributing to ensuring an appropriate site is located for the geological disposal facility for radioactive waste. The construction may follow guidance set out in the UK Government's Waste Strategy (2007) by implementing the waste hierarchy.</p> <p>Post-completion testing and baseline monitoring: Post-completion testing and baseline monitoring are unlikely to have a significant effect on compliance with UK Government policies on sustainable development. However, the activities should meet the requirements of relevant legislation.</p> <p>Assumptions and uncertainties: Site investigation marks the start of the implementation of the long-term management of radioactive waste in a sustainable manner and is therefore it is assumed that it is likely to support the UK Government's aims of sustainable development.</p> <p>It is assumed that the site investigation works for the Derived Inventory Reference Case excluding Plutonium (Pu)/Uranium (U) would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any significant difference in potential effects.</p> <p>Proposed Mitigation/Enhancements: All site investigation works should adhere to relevant legislation and best practice guidance. Where possible minimum requirements should be exceeded as should any planning conditions relating to planning permission for the works.</p> <p>Summary of information requirements: As site(s) specific information becomes known, relevant regional and local planning policies may be identified (e.g. within the relevant Regional Spatial Strategy (RSS) and Local Development Framework (LDF) or equivalent). The effects in relation to these policies would require assessment once potential sites have been identified, and site investigation work activities amended where necessary to ensure compliance.</p>	
B. Lower Strength Sedimentary Rock	
<p>The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 1A. Higher Strength Rocks), as the rock type would not affect the site investigation activities required.</p> <p>No effects and mitigation in addition to those identified for the higher strength rock type are anticipated.</p>	
C. Evaporite Rock	
<p>The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 1A. Higher Strength Rocks), as the rock type would not affect the site investigation activities required.</p> <p>No effects and mitigation in addition to those identified for the higher strength rock type are anticipated.</p>	
Headline Issues	
+	<ul style="list-style-type: none"> - The surface-based site investigations would support UK Government commitments for the long-term management of radioactive waste. <p>It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>



2. Landscape and Visual

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: There are unlikely to be any significant landscape and visual effects associated with the regional survey activities.

Deep borehole construction: It is assumed that drilling campaigns would be undertaken within two areas, each of around 50km². Each area is anticipated to contain up to 16 deep borehole drilling pads, each with a footprint of approximately 0.01km² (a total land take of around 0.16km² of the total area for deep borehole drilling pads). Further land take within the area would also be required for the construction of access tracks and the central office compound, and for shallow borehole drilling campaigns. There would be the potential for this land take to have a landscape and visual effect where the land take results in the fragmentation or loss of key landscape elements or features, or where the introduction of the drilling campaign infrastructure significantly alters the landscape character.

There may be a detrimental effect on landscape character from borehole drilling campaigns due to the introduction of new elements for up to 8 years (particularly hardstanding surfaces at each of the drilling pads, access roads and the central compound), which may contrast with the existing landscape. Effects on landscape character could be direct (where the areas are located within a designated area of landscape value), or indirect (where the setting of the surrounding landscape is affected).

There could also be a negative visual effect through the introduction of new elements into existing views or the loss of views, particularly the erection of drilling rigs at the boreholes, which are assumed to be of a similar scale to a large pylon or large lorry mounted crane.

Lighting would also be required throughout the drilling campaigns (e.g. around the drilling pads, office accommodation and security lighting), which may result in light pollution. Aerial surveys, ground based geophysical surveys and the activities associated with the construction of the drilling pads are likely to be undertaken during daylight hours. However, drilling would be undertaken 24 hours per day, 7 days per week, requiring lighting throughout the night. Some lighting for security purposes would also be in use throughout the night.

At this stage no sites have been selected and consequently the potential scale of any negative effect of the drilling campaigns in landscape and visual terms is uncertain. The scale of any effect would depend on the landscape value of the sites, the surrounding landscape and topography, the degree of urbanisation and the extent of screening. Notwithstanding this, any landscape and visual effect associated with borehole drilling campaigns would be temporary in nature and would affect a relatively small area for each borehole site (lasting the duration of the drilling campaign programme), as following the drilling campaigns it is assumed that the land would be restored to the pre-programme condition. The possible exception to the temporary nature of effects would be any associated facilities required that may remain after completion of the surface-based site investigations (e.g. an off-site office compound or laboratory facility).

It is assumed that construction materials, machinery and any waste associated with the site investigation works would be transported to and from the sites via road. To support HGV traffic to the candidate sites improvements may be made to the local road network. This may have a negative effect on the landscape character of some roads through the possible loss of adjacent border vegetation (e.g. hedgerow, grass verges). The removal of boundary vegetation may increase the visibility of existing and proposed landscape features (e.g. roads, settlements and new development). Increases in traffic on local road networks may also affect these areas. The scale of any effect would be dependant upon the extent of any alteration to the local road network, the sensitivity of any receptors and the extent of any traffic movements.

Post-completion testing and baseline monitoring: There is unlikely to be any significant landscape and visual effects associated with the post-completion testing and baseline monitoring stages of the project.

Assumptions and uncertainties: It is assumed that the sites would be greenfield and, following completion of the drilling campaign would be restored to their pre-programme condition. It is assumed that construction materials, machinery and any waste associated with the drilling campaigns would be transported to and from the sites via road.

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore would not be any difference in potential effects between the different waste inventories.

Proposed Mitigation/Enhancements:

At an early stage following site selection and prior to any site investigation works, consideration needs to be given to the receiving environment and sensitivity of receptors and the potential effects on key views and designated landscape areas. This would enable appropriate mitigation measures to be designed and implemented to have maximum impact in terms of reducing any negative effects.



2. Landscape and Visual

A. Higher Strength Rock (cont)

The loss of existing landscape elements such as woodland, trees, hedgerows and other planting should be avoided where possible through the careful siting and layout of drilling rigs and associated features. Where vegetation within the sites is of value, it should be retained where possible.

Negative effects from the introduction of new visual elements may be reduced by the use of appropriate siting and screening of the drilling pads, central site compound, access tracks and other associated infrastructure (through the use of existing woodlands or copses or temporary earth mounds using excavated soil and suitable grass seed mixes).

It is assumed that the drilling pads and supporting infrastructure would occupy a relatively small area within the wider site area, therefore creating scope to site the infrastructure to reduce any landscape and visual effect that it may have (e.g. in areas of the site that are of low landscape value or well screened).

Buildings should be of a high quality design with due consideration given to the aesthetics of the building in relation to existing local colours and architectural styles. The size of buildings should be kept to a practical minimum.

The colour and texture of surfaces should be considered and attempts should be made to minimise contrast with the landscape. Visual intrusion may be mitigated through the use of appropriate hardstanding materials (e.g. local crushed stone).

The use of fluorescent lighting should be minimised where possible to prevent overspill, glare and light pollution. The number and height of lighting poles should be reduced to a practicable minimum and directional shields used to control light spillage.

Any spoil mounds should be of a scale that is characteristic of the local landscape (e.g. in terms of topography and vegetation). In order to establish vegetation on spoil mounds, it would be necessary to provide some form of growing medium to support plant growth. This would require consideration of the likely availability of soils. Emerging research from WRAP identifies a method of producing topsoil from a mixture of waste aggregate and compost. This method also provides a means of recycling aggregates from the site (http://www.wrap.org.uk/downloads/Soil_Matters.7723a430.7363.pdf).

It may be appropriate to form several screening mounds at different distances from security fences to reflect the landscape character of the site and surrounding area. The ends of these mounds should overlap to maintain a continuous screen around the site. The mound may also be developed in stages, targeting the views of construction works from key visual receptors first.

There is the potential to minimise the negative effect of access roads by linking to the existing road network at the closest point or by linking a number of drilling pads together, rather than linking each directly to the existing road network. The effects on the landscape of the access roads may be mitigated by ensuring that their layout corresponds with natural linear landscape patterns or by being located at the bottom of valleys.

Following completion of the drilling campaigns, the sites should be restored to their former land use. Any landscape features lost as part of the works (e.g. trees or hedgerows) should be replanted on a like for like basis to the same or enhanced quality, with maintenance carried out for a sufficient time to allow any habitat to establish.

There may be opportunities to gather information on landscape character as part of the regional surveys (e.g. ground and aerial surveys could be used to inform landscape characterisation or to aid in the identification and mapping of landscape features). Any opportunities for increased learning during the site investigation works should be pursued.

Summary of information requirements: Information on the receiving environment and sensitivity of receptors is likely to enable a better understanding of the effects that the programme's activities may have. In particular, the next stage of assessment should consider potential effects on key views and designated landscape areas. Such information would enable appropriate mitigation measures to be designed and implemented to have maximum effect on reducing detrimental effects.

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 2A. Higher Strength Rocks), as the rock type would not affect the site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.



2. Landscape and Visual

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 2A. Higher Strength Rocks), as the rock type would not affect the site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- The potential for drilling campaigns to result in the fragmentation or loss of key landscape elements or features.
- The potential for drilling campaigns to have a negative visual effect (particularly the drilling rigs) through the introduction of new elements into existing views or the loss of views.
- The potential for lighting required for drilling campaigns and site security (operating on a 24 hour basis) to result in light pollution.

It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.

3. Cultural Heritage

A. Higher Strength Rock

Assessment of Effects:

Regional Surveys: 2D seismic survey techniques used for the regional surveys require the use of explosives and/or vibroseis trucks to generate seismic waves. These survey techniques would be unlikely to cause structural damage to surface or subsurface archaeology or listed buildings as vibrations would need to be kept within acceptable limits.

Deep borehole construction: Drilling campaigns, particularly construction of the borehole drilling pads, access roads and support infrastructure, could result in the direct loss of or damage to visible above ground cultural heritage or archaeological features within the development footprint.

Drilling campaigns may also have a negative effect on the setting and amenity of above ground historic or archaeological features and landscapes (e.g. world heritage sites, conservation areas, listed buildings, scheduled monuments and registered parks and gardens) within the vicinity of the sites.

Activities associated with the drilling campaigns have the potential to result in the direct loss of or cause damage to subsurface or buried archaeological remains. This may include known archaeology (such as designed or recorded sites) or previously unknown archaeology. Generally, there would be limited potential for archaeology below a depth of 1-2m (with the exception of historic mine workings), with any remains typically found within the soils above the drift geology. The greatest potential for effects on subsurface or buried archaeological remains would therefore be during construction of the borehole drilling pads, support infrastructure and access roads (e.g. stripping topsoil, site levelling, digging foundations and piling) and during shallow surface investigations (e.g. trial pitting and trenching, and shallow borehole drilling). Drilling activities at a depth greater than 2m would be unlikely to affect subsurface or buried archaeological remains and there would be limited potential for archaeological remains within the higher strength rock (assuming there are no historic mine workings).

The extensive ground and aerial surveys may identify the location of any archaeology before construction or drilling takes place, although as the geophysical 2D seismic survey would be undertaken at a district level, approximately 600km², there would be a significant chance that it may miss local archaeological features.

It would be unlikely that there would be any significant effects on traditional activities in the area due to the drilling campaigns, unless the works result in the loss or fragmentation of land used for such activities (e.g. farming).



3. Cultural Heritage

A. Higher Strength Rock (cont)

There would be the potential for pollution from engine exhausts and vibration associated with the increase in traffic (particularly HGVs, anticipated to involve a total of 130-260 movements per borehole, which is equivalent to 5 -10 movements per week over a 6 month construction period) to affect historic or archaeological features (e.g. listed buildings) by accelerating corrosion. However, given the small number of anticipated transport movements and the relatively small scale nature of the operations any potential effect would probably not be significant.

Post-completion testing and baseline monitoring: Post-completion testing and baseline monitoring activities would be unlikely to have any significant effects on cultural heritage and archaeology.

Assumptions and uncertainties: It is assumed that construction materials, machinery and any waste associated with the drilling campaigns would be transported to and from the sites via road. Construction traffic may have to use local roads (e.g. lower order, B and C roads) to reach the sites and may pass close to sensitive receptors such as residential areas.

At this stage no sites have been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the surface-based site investigations to any cultural heritage and archaeological sites, features and landscapes, the condition and sensitivity of the site/feature/landscape affected and the level of disturbance or loss.

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any difference in potential effects between the different waste inventories.

Proposed Mitigation/Enhancements:

It is anticipated that any significant detrimental effects arising from surface-based site investigation works on cultural heritage and archaeology, including subsurface and buried archaeology and traditional activities, may be minimised through early liaison with, and adhering to guidance issued by English Heritage, the National Trust and other appropriate organisations.

At an early stage following site selection and prior to any works on site, a desk study and site walkover should be undertaken to determine the historic and archaeological value of the sites in consultation with English Heritage, the relevant local authority heritage officer and other relevant bodies. This would identify the need for further site evaluation such as: hedgerow surveys to identify those that may be classified as 'important' for their archaeological or historical value under the Hedgerow Regulations 1997; field walking; monitoring and assessment of geotechnical work, including a watching brief on geotechnical test pits; geophysical survey; trial trenching; and other specialist surveys. Further site evaluation, such as those listed, should be undertaken if the initial desk study and site walkover indicate a potential for significant effects.

Mitigation requirements would be dependant on the sites selected and their existing cultural heritage and archaeology value. These might include alterations to the construction methodology (e.g. foundation design) in order to minimise effects or the retention of historic or archaeological features in situ. If retention of any features is not possible, consideration should be given to moving features to another location or storage, or detailed excavation and recording of the affected feature should be undertaken. A watching brief is recommended during topsoil stripping and excavation in order to identify any unexpected features or artefacts arising during the works. Where features may be affected, the use of angled drilling should be considered if appropriate.

Identifying appropriate routes to access the site would help to minimise potential negative effects on historic or archaeological features (e.g. listed buildings) caused by transport pollution and vibration.

Where there is the potential for adverse effects on the setting of cultural heritage and archaeological sites and features, where possible facilities and infrastructure should be appropriately sited to reduce any effect and the footprint of the works minimised as far as practically possible. This would also help to reduce any potential landscape and visual, soils, biodiversity, water and land use effect of the works (refer to Sustainability Themes 2 to 6 and 11 respectively).

There may be opportunities to gather information on cultural heritage and archaeology as part of the regional surveys (e.g. ground and aerial surveys could be used to inform historic landscape characterisation or to aid in the identification and mapping of features and assets). Any opportunities for increased learning during the site investigation works should be pursued.

Summary of information requirements: Site-specific information is required to establish the likelihood of any effects upon above ground cultural heritage or archaeological features and their settings, and the likelihood of encountering archaeological remains (refer to the desk study and site walkover mitigation).



3. Cultural Heritage

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 3A. Higher Strength Rocks), as the rock type would not affect the activities required for surface-based site investigations.

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 3A. Higher Strength Rocks), as the rock type would not affect the activities required for surface-based site investigations.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

?	<ul style="list-style-type: none"> - Potential for activities associated with deep borehole construction campaigns to result in the direct loss of or damage to visible above ground cultural historic or archaeological features and landscapes. - Potential for deep borehole construction campaigns to have a negative effect on the setting and amenity of below ground historic or archaeological features and landscapes. <p>At this stage no sites have been selected and subsequently the effect is uncertain. The potential for effects would depend upon the proximity of the surface-based site investigations to any cultural heritage and archaeological sites, features and landscapes, the condition and sensitivity of the site/feature/landscape affected and the level of disturbance or loss.</p> <p>It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.</p>
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4. Geology and Soils

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: There would probably not be any significant effects on the condition or quality of soil or geology associated with regional surveying activities.

Deep borehole construction: There would be some loss of topsoil and sub-soil during the construction of the borehole drilling pads, support infrastructure and access roads (e.g. due to topsoil stripping, site levelling and digging foundations). Any loss would be for the duration of the drilling campaigns with the soil being stored during the interim. It is likely that any topsoil would be used for temporary landscaping and subsequently reinstated as part of the restoration of the sites following completion of the borehole drilling campaigns. The topography of the sites would determine the degree to which they would need to be levelled and the subsequent amount of spoil arising.

There would be the potential for the removal and storage of topsoil to affect the nutrient content and fertility of the soil, depending on the soil classification. Although this could be addressed through the use of fertilisers/soil conditioners.

The drilling campaigns are estimated to result in the removal of between 75 and 100m³ of rock per year, which would be taken away for testing and analysis. Depending on the level of contamination, once the rock is no longer required it is anticipated that the drilling cuttings would be disposed of to landfill or as hazardous waste.

There is the potential for borehole drilling campaigns to affect sites of recognised importance for their geological value (e.g. SSSI or RIGS), although the designation is typically determined by the surface geology rather than the deeper stratigraphy. Such effects would be site specific and therefore the potential effect on sites of geological value is uncertain at this stage.



4. Geology and Soils

A. Higher Strength Rock (cont)

Similarly, there would be the potential for the drilling campaigns within higher strength rock to result in the sterilisation of a minerals resource, or a minerals reserve (where a site is covered by valid planning permissions for the extraction of minerals), at minimum for the duration of the site investigation works. Sterilisation occurs when other non-minerals development takes place on, or close to, mineral deposits, rendering them incapable of being extracted. The likelihood of this would depend on the site locations.

It has been assumed that the sites would be greenfield and therefore it would be unlikely that any ground contamination from previous land uses would be encountered. However, this would be dependant on the eventual location selected and should be considered further. There would be the potential for some of the activities associated with drilling campaigns to introduce some low level contamination to soils around the borehole and drilling pad (including, for example, silty water, drill fluid and oil spillages), although this could be sufficiently mitigated following best practice guidance. Any contaminated soils would need to be remediated before reinstatement.

Borehole drilling could create new rock fractures (or increase the existing fracture network) which in turn could reduce the mechanical strength of the rock, increase its hydraulic permeability and/or create local new flow pathways for water. The latter has the potential to adversely affect rock chemistry locally (i.e. weathering). However, the drilling methodologies would be chosen to minimise these impacts as such fracturing would have a detrimental affect on the quality of the data acquired from investigations. It is considered that any residual effects would therefore be negligible and would be spatially limited to the immediate vicinity of the drilling activities.

Post-completion testing and baseline monitoring: There are not anticipated to be any significant effects on the condition or quality of soil or geology associated with post-completion testing or baseline monitoring. There may be a negative effect on soil degradation from the reinstatement of soils following completion of the site investigation works, although this could be sufficiently mitigated against following best practice guidance on soil handling and storage.

The post-completion monitoring along with the earlier geological surveying would provide a wealth of additional information on a range of geological issues, potentially including paleoclimatic information, which may have wider benefits in terms of our understanding of geological processes.

Assumptions and uncertainties: It is assumed that the sites would be greenfield with no previous history of contamination. Subsequently, it is unlikely that the surface-based site investigations would result in the mobilisation of contaminants through the soil profile.

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory, and therefore there would not be any significant differences in potential effects between the different waste inventories.

Proposed Mitigation/Enhancements:

Activities that may affect directly or indirectly any geological features of value (e.g. Sites of Special Scientific Interest (SSSIs) or Regionally Important Geological Sites (RIGS)) should be avoided, unless no other suitable location can be identified.

At an early stage following site selection and prior to any intrusive investigation works on site, surveys should be undertaken to identify different soil materials on the site.

All surface-based site investigations should be undertaken in accordance with British Standard (BS) 5930: 1999, Code of Practice for Site Investigations and other relevant British Standards or equivalent as applicable. Tender specifications should request a method statement providing information on how measures would be implemented to mitigate environmental effects.

Good practice guidance in the protection of soil materials should be followed: Guidance on Good Practice for the Reclamation of Mineral Workings to Agriculture (Department of Environment (DoE), 1996) and Good Practice for Handling Soils (Ministry of Agriculture, Fisheries and Food (MAFF), 2000).

The sites should be carefully stripped of topsoil prior to construction works commencing to avoid damage. All soils should be handled in suitable conditions (e.g. dry weather) and the most appropriate method of soil handling should be used.

Soils should be stored in allocated heaps and protected from erosion, contamination or degradation. Different soil types and topsoil/subsoil should be stored separately and the length of time soils are stored should be minimised where possible. If there are concerns that the length of time it has been stored has affected its nutrient content (due to the effects of rainwater leaching), the use of nutrient supplements and soil conditioners could be considered when returning the site (and soil to its previous use).



4. Geology and Soils

A. Higher Strength Rock (cont)

Soil excavation and mounds should avoid compaction where possible by making use of appropriate wide tracked vehicles and avoiding working on soil when it is wet. Appropriate drainage systems should be utilised on site to reduce soil erosion. Spoil mounds should be shaped to shed rainwater. A suitable grass seed mix could be used to provide a vegetation cover and reduce the risk of soil erosion from surface run-off.

Opportunities for the beneficial re-use of drilling cuttings should be explored (e.g. re-use of cuttings as a secondary aggregate). When considering the viability of any options, commercial, technical and environmental factors should be explored.

Summary of information requirements: The location of the site would enable more detailed mitigation measures to be explored relating to the reinstatement of the soil as the existing land use would be known. Similarly, the potential chemical contamination of soils may be assessed in more detail at a later stage. Site-specific information is required to establish the likelihood of any effects on designated geological sites and mineral resources or reserves.

B. Lower Strength Sedimentary Rock

The potential effects and mitigation/enhancements relating to soils, sites of geological importance and the physical and chemical stability of the host rock are considered to be the same as those identified for higher strength rock (refer to 4A. Higher Strength Rocks).

In the case of the lower strength sedimentary rock type, deep borehole construction is not considered to have a significant effect on minerals resources or reserves, as lower strength argillaceous sedimentary rocks have limited commercial value.

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 4A. Higher Strength Rocks).

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- 'Temporary' loss of topsoil during construction activities for the borehole drilling campaigns.
- Loss of rock from borehole drilling campaigns (drill cuttings).
- Potential for borehole drilling campaigns to affect sites of recognised importance for geological value.
- Potential for borehole drilling campaigns within the higher strength rock and evaporite rock to result in the sterilisation of a minerals resource, or a minerals reserve where a site is covered by valid planning permissions for the extraction of minerals.

It is assumed that site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar as those for the Derived Inventory Upper Inventory, and therefore there would not be any significant difference in potential effects between the different waste inventories.

- In the case of the higher strength rock and evaporite rock types there would be the potential for drilling campaigns to sterilise a mineral resource or reserve, as these host rocks could be of commercial value. The lower strength sedimentary rock type would be unlikely to have an effect on mineral resources or reserves, as the commercial value of the lower strength sedimentary rock would be limited.



5. Water

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: There would probably not be any significant effect on water resources as a result of the regional surveying activities.

Deep borehole construction: Water would be required throughout the borehole drilling campaigns for use in construction activities (e.g. for drilling fluid, cleaning machinery, dust suppression, pressure testing, cooling equipment etc). During the campaigns, water would also be used for potable purposes such as drinking water and canteen use as well as toilet and washing facilities. The anticipated increase in water use is estimated to be approximately 1,000m³ per borehole for the borehole drilling and 16 litres per employee per day (which is consistent with BRE best practice targets of 4m³ per employee per annum, assuming normal office hours).

Potential sources of supply include the use of mains supply water or surface or groundwater abstraction. Depending on local water resource availability and demand at the sites, there would be the potential for water use to affect the availability of water for other licensed water abstractors within the catchment, or for environmental flow targets to be adversely affected. This would be assessed in the determination of any new abstraction licences by the Environment Agency (EA) or equivalent regulator.

The installation of boreholes could have localised effects on the pattern of groundwater flows in the area of the borehole, acting as a barrier to normal flow patterns (where boreholes are lined with an impermeable lining or where equipment is present within the boreholes). Borehole drilling may also produce fracture zones in the rock which act as conduits for groundwater. However, any effects would be localised and only for the duration of the drilling campaigns.

Activities associated with borehole construction would generate several sources of water requiring discharge. Such discharges could affect the water quality and/or rate of flows of receiving waters. Surface run-off could contain contaminants released through spillage of materials used during the drilling campaigns such as chemicals, oils and fuels. Drilling activities may also introduce contaminants to groundwater sources (e.g. drilling fluid), and water used as drilling fluid is likely to have a high sediment load, which could affect water quality if discharged untreated. However, it is assumed that any water would be treated prior to discharge, therefore reducing the potential for significant effects on water quality.

The construction of the borehole drilling pads, support infrastructure and access roads may increase flood risk, due to changes to surface drainage patterns and the increase in impermeable surface areas, affecting surface run-off rates and flow pathways.

Post-completion testing: There would be an increase in water abstraction during post-completion testing, involving long-term but probably low rate pumping tests operating 24 hours a day, 7 days a week, across a network of boreholes.

Baseline monitoring: There would probably not be any significant effect on water resources as a result of the baseline monitoring activities.

Assumptions and uncertainties: The drilling pads are assumed to be areas of crushed stone gravel underlain by an impermeable textile membrane. The significance of the effect on flood risk would be dependent, in part, on whether the drilling pads are situated in a flood risk area, which at this stage is uncertain.

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any significant difference in potential effects between the different waste inventories.

Proposed Mitigation/Enhancements:

Where possible, drilling pads and support infrastructure should be located to minimise any effect on hydrology as far as possible. Surface mapping can inform the identification of areas that may be most at risk and allow a concentrated focus on prevention.

Potential sources of water resources for use during works should be identified at an early stage and abstraction from the source should result in the lowest environmental effect possible.

Design for surface water drainage should incorporate sustainable techniques (SUDS) where possible which include surface storage and attenuation, and infiltration to ground if near-surface hydrogeology is suitable. Assuming the sites are greenfield, run-off from rainfall should be limited to greenfield rates, and this would be agreed with the EA or equivalent body prior to design. In line with the requirements of PPS25 and other equivalent policies, SUDS should be used to attenuate any increases in surface run-off rates.



5. Water

A. Higher Strength Rock (cont)

All site investigations should be undertaken in accordance with BS 5930: 1999 (Code of Practice for Site Investigations), ISO 5667-11:2009, BS 6068-6.11:2009 (Guidance on sampling of groundwaters) and other relevant BS or equivalent as applicable.

Tender specifications should provide information on site investigations requirements and include a method statement providing information on how measures would be implemented to mitigate potential effects on water resources.

Measures to reduce the risk of pollution incidents and accidental discharge and to control the rates of water discharged from the sites should be outlined within an Environmental Management Plan. These should follow best practice pollution prevention guidelines produced by the EA or equivalent bodies. Measures include the use of impermeable membranes, bunded and tanked fuel storage, double lined settlement lagoons and oil/water interceptors.

All discharges off-site would need to be agreed with the EA or equivalent body. Discharges to surface water or groundwater would require EA consent.

Settlement lagoons should be adequately protected through the use of double linings to prevent loss and appropriately sited to mitigate the risks of contaminating groundwater or surface water bodies in case of flooding.

The handling of any hazardous materials or fluids must be carried out in accordance with relevant best practice guidance and make use of bunds and suitable storage tanks effectively providing sealed areas with adequate storage and collection facilities.

A Spillage Response Plan should be developed and implemented, which sets out systems to ensure that pollution effects are contained and minimised and that clean-up procedures and spill kits are in place to respond effectively once an incident is discovered. Training should be provided to all staff working on the site on the spill response procedures and periodic auditing of the procedures should take place. Sufficient spill kits should be provided and maintained and the contents should be subject to periodic checks.

Drilling specifications should ensure appropriate design of both drilling fluid and use of casing to prevent entry of drilling fluids to groundwater.

Drilling specifications should allow for full solids removal from drill cuttings and ensuring that the reuse of drill muds is maximised (within the constraints imposed by hydrochemical sampling requirements). Regular monitoring of fluid flows and stored volumes should also form a component of the drilling specifications.

Testing specifications should ensure that sufficient safe water storage is in place to allow for of the order of 1 weeks' discharge to be stored on site prior to removal.

Implementation of water efficiency and re-use measures on site (demand management techniques, grey water recycling and rain water harvesting) should be implemented where appropriate, to minimise demand for water resources and any consequential environmental effect.

A Flood Risk Assessment (FRA) should be carried out which assesses all potential sources of flood risk and identifies any mitigation measures necessary to ensure flood risk at the sites or downcatchment are not increased during the borehole drilling campaigns. The FRA should include a surface drainage strategy which details how run-off from rainfall would be discharged at rates no higher than those from the pre existing conditions, and preferably at lower rates, up to the 50 year rainfall event, allowing for climate change. The FRA should meet the requirements of PPS25: Development and Flood Risk (England), TAN 15 (Wales) or other equivalent policy.

All boreholes should be decommissioned in accordance with best practice guidance (i.e. EA and National Groundwater and Contaminated Land Centre guidance, Decommissioning Redundant Boreholes and Wells or equivalent).

Summary of information requirements: Site-specific topographic and geological information would be essential to support rigorous design and specification of detailed mitigation measures. Regulatory discharge and abstraction permitting would also be site-specific.

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 5A. Higher Strength Rocks), as the rock type would not affect the activities required for surface-based site investigations.

No effects in addition to those identified for the higher strength rock type are anticipated.



5. Water

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 5A. Higher Strength Rocks), as the rock type would not affect the activities required for surface-based site investigations.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- Potential for discharges associated with borehole construction to negatively affect water quality and/or rate of flows of receiving waters.
- Potential for the construction of the borehole drilling pads, support infrastructure and access roads to increase local flood risk due to changes in surface drainage patterns and the increase in impermeable surface areas.
- Increase in water use during borehole drilling campaigns and post-completion testing, which has the potential to negatively affect water availability for other licensed abstractors, or for environmental flow targets to be adversely affected.

It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there would not be any significant difference in potential effects.

6. Biodiversity, Flora and Fauna

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: The regional surveys would probably not have any significant effects on wildlife or habitats due to the limited duration and scale of the activities.

Deep borehole construction: Activities associated with the deep borehole construction could affect biodiversity associated with the sites and their surrounds. The key effects can generally be characterised as habitat loss, habitat change, disturbance of fauna, alteration of hydrological regimes and the deposition of pollutants on to surrounding areas (mostly associated with increased volumes of traffic).

Potential receptors that may be affected, depending on the specific site location include statutory designated sites (e.g. Special Area of Conservation (SAC), Special Protection Areas (SPA) and SSSI), non statutory designated sites (e.g. Sites of Nature Conservation Interest/Importance (SNCI) or County Wildlife Sites) and other protected and notable habitats and species.

The greatest potential effect would be loss of habitat and disturbance/displacement of conservation notable species from an area and its surrounds as a result of the deep borehole construction and from vehicle movements. Loss of habitat could be both direct (e.g. loss to hard engineering such as the drilling pads) and indirect (e.g. changes in character due to alterations in drainage patterns and deposition of pollutants) and could result in fragmentation of surrounding habitats.

Disturbance/displacement of fauna could be caused by a range of factors such as noise, human presence and light pollution. The effect of disturbance has the potential to reduce the rates of breeding success and survival resulting in falls in the size of local populations of fauna. The potential for substances associated with the works (e.g. diesel, drilling fluid) and silt laden run-off to escape into the surrounding environment has the potential to affect notable flora and fauna as does the increased deposition of pollutants associated with HGV movements.

There would be the potential for the construction of access roads to affect biodiversity (e.g. the works may result in the loss or fragmentation of habitat and displacement/disturbance of species). Similarly, any improvements to the local road network required to support traffic to the sites may result in the loss of habitat due to widening/structural upgrading. This is not anticipated to be significant, although there is the potential for localised issues such as species rich hedgerows and specimen trees to be affected.

Post-completion testing and baseline monitoring: The activities associated with post-completion testing and baseline monitoring would probably not have any significant effects on wildlife or habitats due to the limited duration and scale of the activities.



6. Biodiversity, Flora and Fauna

A. Higher Strength Rock (cont)

Assumptions and uncertainties: It is assumed that the sites would be greenfield. It is assumed that construction materials, machinery and any waste associated with the drilling campaigns would be transported to and from the sites via road.

At this stage no sites have been selected and subsequently the effect on biodiversity is uncertain. The potential for effects would depend on the biodiversity value of the sites and their surrounds, the sensitivity of any habitats/species present, and the level of habitat disturbance or loss.

It is assumed that the surfaced based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any significant difference in potential effects between the different waste inventories.

Proposed Mitigation/Enhancements:

At an early stage following site selection and prior to any works on site, a desk-based assessment followed by surveys (site walkover surveys followed by detailed species specific surveys in areas likely to be subject to direct disturbance) as appropriate should be undertaken to determine the biodiversity value of the sites.

Extensive short-term site investigation surveys should avoid breeding seasons.

Valuable biodiversity habitat or features should be retained where possible and any loss minimised as far as practically possible. Habitat fragmentation should be avoided by minimising the removal of habitat wildlife corridors. It is assumed that the drilling pads and supporting infrastructure would occupy a relatively small area within the wider site area, therefore creating scope to site the infrastructure to reduce any biodiversity effect that they may have.

Careful consideration should be given to the routing of access roads to prevent/minimise habitat fragmentation.

The containment of spillages and run-off and control of ground water pollution (e.g. through drilling) should be managed appropriately following standard pollution prevention guidance incorporating measures such as bunding, oil/water interceptors, silt fencing and flocculation techniques (refer to Sustainability Theme 5A). These measures should be detailed within an Environmental Management Plan, implemented and adhered to on site.

Careful monitoring and control of drilling fluids should be exercised to prevent their entry into groundwater where they may seep into other aquatic environments.

Any opportunities for habitat creation or enhancement, such as any opportunities to contribute towards or meet Local Biodiversity Action Plan targets, should be pursued (e.g. the use of visual screens, spoil heaps and sustainable drainage systems to create wildlife habitat). Any planting should comprise native species that provide habitat for affected ecosystems.

The reinstatement of the site should ensure that habitat is restored to its previous condition and where possible enhanced into a more favourable condition. A management plan should be put in place where necessary to ensure proper growth and re-establishment.

Where an effect cannot be adequately mitigated then appropriate compensation measures would need to be developed.

Summary of information requirements: Future assessments should take account of the type, features and conservation characteristics of habitats in the area, especially any designated areas (e.g. SSSI, SAC, Ramsar etc). Species diversity and their conservation designation should be considered to accurately gauge the likely significance of the effects.

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 6A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.



6. Biodiversity, Flora and Fauna

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 6A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

?	<ul style="list-style-type: none"> - Potential loss or fragmentation of habitat within the site area as a result of the deep borehole construction activities (e.g. direct loss of habitat to hard engineering such as the borehole drilling pads, central site compound and access roads). - Potential for the disturbance/displacement of conservation notable species from the sites and their surrounds as a result of deep borehole construction and post-completion testing activities (e.g. such as noise, human presence and light pollution). <p>At this stage, no sites have been selected and subsequently the effect is uncertain. The potential for effects would depend on the biodiversity value of the sites and their surrounds, the sensitivity of any habitats/species present, and the level of habitat disturbance or loss.</p> <p>It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there is not considered to be any significant difference in potential effects.</p>
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7. Traffic and Transport

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: There may be short-term disruption to local traffic from the regional surveying activity (e.g. seismic surveys on rural road networks), although this is unlikely to be significant.

Deep borehole construction: There would be a notable increase in traffic movements on the local road network around the sites throughout the deep borehole construction phase, associated with site staff/personnel, HGVs, a range of heavy plant construction vehicles and deliveries.

There would be an increase in localised traffic associated with construction activities for the drilling campaigns (construction of the borehole drilling pads, support infrastructure and access roads), assumed to be operating for 5 days a week in advance of the deep borehole drilling phases, over 6 years (up to 16 locations at each site). Construction is anticipated to take approximately 10 days for preparation, 6 months per borehole construction, and a further 10 days for reinstatement. It is anticipated that there could be up to 10 HGV movements per week to each drilling site during the construction of the boreholes to transport materials for the drilling rig.

Assuming that borehole construction would operate on a 24/7 basis, once borehole drilling has commenced the drilling operations are expected to require a total of 4 drill crews of between 5 and 10 people. This assumes that 2 drill crews operating equal shifts per day would be required, substituted by the other 2 drill crews in line with legislation governing working hours. Therefore, there would be approximately 4 vehicle movements per day, 7 days per week to transport crew to and from the site for drilling operations (2x there and 2x return). An additional 3 to 4 people would be required to supplement the drill crews at any one time, with up to 10 on a sporadic basis.

Taking account of the size of the central office compound, up to 150 people could be on each site Monday to Friday as the investigations progress, (assuming the central office compound would operate a 5 day normal working week) over the 8 years of the surface-based site investigation programme.

Effects that could be considered as potentially significant on the road network include disruption to pedestrians/cyclists induced by the flow of vehicles along a road, driver delay, loss of pedestrian/cyclist amenity, and accidents and safety as a result of an increase in traffic on the highway network.

The significance of the traffic and transport effects of the surface-based site investigations would depend on the location of the sites, traffic generation, the sensitivity of the local highway network and traffic routing. This may affect the range of measures that are implemented to mitigate traffic related environmental effects.



7. Traffic and Transport

A. Higher Strength Rock (cont)

Post-completion testing and baseline monitoring: There is unlikely to be a significant effect on traffic and transport as a result of the post-completion testing and monitoring activities as the number of staff would be lower than at peak drilling periods, however, levels of light vehicle traffic would be greater than before start of the surface-based site investigations.

Assumptions and uncertainties: It is assumed that construction materials, machinery and any waste associated with the drilling campaigns would be transported to and from the sites via road. It is also assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the sites and may pass close to sensitive receptors such as residential areas.

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory, and therefore there would not be any significant differences in potential effects between the different waste inventories.

Proposed Mitigation/Enhancements:

Where practicable, consideration should be given to the use of more sustainable modes of transport such as rail. Alternatives, where practical could reduce potential road traffic effects associated with the works. When considering the viability of any options, commercial, technical and environmental factors should be explored.

To minimise the movement of construction materials, locally sourced construction materials should be used where practicable and, where possible, any construction waste should be retained and used on site.

To reduce traffic effects associated with deep borehole construction, the following mitigation should be implemented:

Tender specifications should provide information on traffic management requirements and request information on how measures would be implemented to mitigate traffic and transport effects.

A road safety audit of the site access design should be undertaken prior to site investigation works commencing to ensure that the access is an appropriate design, capable of accommodating construction traffic, and would not compromise safety on the public highway.

A Traffic Management Plan (TMP) should be prepared and adopted. The TMP is likely to include details on car parking, temporary road signage and traffic routing and timing.

Traffic movements (particularly HGVs) should be limited along certain routes or at certain times of the day to minimise the effects of congestion and nuisance/intrusion on any nearby residents.

Similarly, a Green Travel Plan should also be developed and implemented for the office facilities, outlining measures to minimise private vehicle use such as the promotion of car sharing, the provision of services for workers to the site (i.e. buses) and the provision of public transport passes to encourage use where appropriate.

Routing strategies should be implemented for construction material transport in order in order to avoid, as far as possible, sensitive receptors and congestion effects. Deliveries should be co-ordinated by a logistics manager to prevent queuing of vehicles. Arrivals of materials should also be scheduled to outside of peak hours to minimise any disruption to the existing highway network.

The immediate area external to the sites, including the site entrances and adjacent road/footpath, should be subject to regular sweeping and washing using a combination of manual and mechanical means. Lorries should pass through wheel washing installations prior to departure in order to minimise dirt on the roads.

A regularly serviced modern lorry fleet should be used for the collection of waste, transportation of plant and equipment.

Contributions could be made towards improving the road network and public rights of way where appropriate.

Summary of information requirements: The effects on users of existing transport network and infrastructure may be made at the next stage of assessment by considering traffic flows for local road networks. Similarly the requirements for new or improving existing infrastructure may also be identified.



7. Traffic and Transport

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 7A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 7A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- Increase in traffic movements on the local road network throughout the deep borehole construction phase, with potential disruption to pedestrians/cyclists induced by the flow of vehicles along a road, driver delay, loss of pedestrian/cyclist amenity and safety implications.

It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there is not considered to be any significant difference in potential effects.

8. Air Quality

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: The regional survey activities are unlikely to have a significant effect on air quality as they would not involve high levels of pollutant emissions. Effects on air quality from the airborne surveys would probably be negligible as they involve a single aircraft and any airborne survey activity would occur for less than 10% of the total programme time.

Deep borehole construction: Dust generated during construction activities, particularly earthworks, soil stripping, storage of materials and drilling, could have an effect on local air quality if unmanaged.

Exhaust emissions from vehicle movements during the borehole construction campaigns (refer to Sustainability Theme 7A) may lead to a decrease in local air quality, particularly from nitrogen oxides, nitrogen dioxide and particulates (assuming that construction materials, machinery and waste associated with the site investigation phase would be transported to and from the site via road). Similarly, exhaust emissions from construction plant and diesel engine emissions from diesel generators used to supply non mains power may also contribute to increases in particulate matter and gaseous pollutants (particularly nitrogen dioxide and carbon dioxide). However, given the small number of anticipated HGV movements (5 to 10 per week) and relatively small scale nature of the operations any decrease in local air quality is unlikely to be significant.

There would be the potential for dust or pollutant emissions to be noticeable to nearby sensitive receptors (e.g. residents) where up to 3 drilling pads are anticipated to be within 1km of each other due to the cumulative effect. If emissions are likely to be spread across the whole site area (50km² for each site) they could be sufficiently dispersed to prevent noticeable concentrations. Furthermore, all equipment would comply with UK Government emissions regulations and is expected to be sited to minimise effects on nearby sensitive receptors. However, this would depend on the existing air quality in the area prior to construction.

Post-completion testing and baseline monitoring: There is unlikely to be any significant effects arising from the post-completion testing or baseline monitoring activities other than light vehicle traffic movements associated with staff travelling to and from the sites.

Assumptions and uncertainties: It is assumed that construction materials, machinery and any waste associated with the drilling campaigns would be transported to and from the sites via road.



8. Air Quality

A. Higher Strength Rock (cont)

It is also assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the sites and may pass close to sensitive receptors such as residential areas.

Uncertainties arise through the lack of specific information of the locality and receptors in the area. The magnitude and significance of effects from emissions to air would depend on the location of the site and sensitivity of the local environment and the proposed traffic routing and journeys neither of which can be fully addressed at this stage.

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any significant differences in potential effects.

Proposed Mitigation/Enhancements:

As noted in Sustainability Theme 7A (Traffic and Transport), where practicable consideration should be given to the use of more sustainable modes of transport such as rail. Measures to reduce private vehicle use and transport distances should also be implemented. When considering the viability of any options, commercial, technical and environmental factors should be explored.

Measures to reduce the effects of increases in vehicular pollutant emissions and particulate matter should be implemented where possible. This could include: eco-driver training; ensuring all vehicle engines and plant on site are not left running; using low emission vehicles and plant fitted with catalysts, diesel particulate filters or similar devices; keeping plant well maintained and routinely serviced; requiring that all vehicles comply with exhaust emission regulations for their class; siting haul routes, and operating plant away from sensitive receptors (e.g. houses and schools); and maximising energy efficiency.

Where possible, the use of mains electricity to power equipment and plant would be preferential to diesel or petrol powered generators. The potential for renewable energy generation (e.g. solar panels, dedicated wind turbines, ground source heat pumps or biomass boilers) to meet energy needs at the central office compound should be considered. Where practicable, activities should be scheduled in the summer months to avoid the need to use generators for lighting.

Any risk of causing nuisance dust arising from works should be reduced by making use of Best Available Techniques and selecting suitable energy efficient, low emission equipment.

The following measures to suppress dust should be implemented: the use of wet sweeping and cleaning methods; use of vehicle wheel wash facilities; the enforcement of low speed limits along temporary roads; paving of haul routes on site even if temporary to prevent re-suspension of dust emissions; sheeting vehicles transporting loose or potentially dusty material; delivering fine powder materials in enclosed tankers/silos; storage of dusty materials away from site boundaries; minimising the amount of excavated material held on site; sealing or re-vegetating completed earthworks as soon as reasonably practicable; and the use of design/pre-fabrication to reduce the need for grinding, sawing and cutting.

Mixing of cement, grout and other similar materials should take place in enclosed areas remote from site boundaries and potential sensitive receptors.

The use of dense vegetation, screens and barriers to help reduce the effects of particulate matter should be considered (taking into account landscape and visual and biodiversity implications), as should the orientation with respect to locally prevailing winds.

Summary of information requirements: More detailed information on the location of the site(s) would assist with improving the accuracy of assessing the likely effects. In particular, a more detailed assessment requires further information on the effects of air pollution and dust on sensitive receptors, and any sources of odour that may arise. This would include confirmation of the location and character of the sensitive receptors (such as schools, homes and healthcare facilities). Similarly, further information is required on the levels of specific pollutants emitted and the effect that may have on baseline air quality (e.g. Air Quality Management Areas (AQMAs)).

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 8A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.



8. Air Quality

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 8A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- Potential for exhaust emissions from vehicle movements associated with surface-based site investigations to negatively affect local air quality, particularly the borehole construction phase, which is likely to generate the greatest number of transport movements.
- Potential for exhaust emissions from construction plant and diesel engine emissions from diesel generators associated with drilling activities to result in an increase in particulate matter and gaseous pollutants (nitrogen dioxide and carbon dioxide).
- Potential for dust generated during construction activities to negatively affect local air quality if unmanaged.

It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there is not considered to be any significant difference in potential effects.

9. Climate Change

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: The regional surveying activities are unlikely to result in any significant increase in emissions of greenhouse gases in comparison with the likely baseline condition. The effects of climate change would have a negligible effect during the regional surveying due to the nature of the activities. The use of airplanes for aerial surveys is estimated to result in emissions of the order of approximately 3 tonnes of carbon dioxide (CO₂) in total. The use of 'vibroseis' trucks in carrying out geophysical surveys are estimated to result in emissions of the order of approximately 1 tonne of CO₂ in total.

Deep borehole construction: The emission of carbon dioxide (due to the direct or indirect combustion of fossil fuel) from vehicle movements, any use of diesel generators during the drilling campaigns, and the energy used in the central office compound (including the embodied energy within construction materials used) would contribute to climate change. The construction and operation of 20 deep boreholes is estimated to generate in the region of 2,100 tonnes of CO₂ in total.

It is not anticipated that the boreholes or associated support infrastructure (which could be on site for up to 8 years), would be particularly vulnerable to the effects of climate change other than potential surface flooding from increased frequency and magnitude of storms if located within an area at risk of flooding or surface water run-off was not managed appropriately. The borehole locations would be determined by the requirements for scientific information and may therefore be located within a floodplain or flood sensitive area. Should sites be coastally located, coastal erosion, sea level rise and storm surges could also potentially have an effect.

Post-completion testing and baseline monitoring: The post-completion testing and baseline monitoring is unlikely to result in any significant increase in emissions of greenhouse gases in comparison with the likely baseline condition; with post-completion testing estimated to generate less than 1 tonne of CO₂ in total. The effects of climate change are considered to have a negligible effect during the post-completion testing and baseline monitoring periods due to the nature of the activities.

Assumptions and uncertainties: At this stage no sites have been selected and subsequently the effects of climate change on the site investigation works are uncertain. The specific location of the sites in relation to floodplains or flood sensitive areas and the coastline cause a level of uncertainty when considering the potential for effects.

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any significant differences in potential effects between the different waste inventories.



9. Climate Change

A. Higher Strength Rock (cont)

Proposed Mitigation/Enhancements:

As noted in Sustainability Theme 7A (Traffic and Transport), where practicable, consideration should be given to the use of more sustainable modes of transport such as rail. Measures to reduce private vehicle use and transport distances should also be implemented. When considering the viability of any options, commercial, technical and environmental factors should be explored.

Where possible, construction materials with lower embodied energies should be utilised.

When considering the detail of design and within engineering appraisal, the carbon associated with construction materials should be considered, for example it's source, distance to be transported, method of transport and volume. Where reasonable lower carbon alternatives are available they should be considered.

Construction waste generation on site should be minimised (where transport off-site would to be required) in order to limit carbon emissions associated with this additional transport requirement.

Where practicable, schedule activities in the summer months to avoid the need to use generators for lighting.

Where possible, the use of mains electricity to power equipment and plant would be preferential to diesel or petrol powered generators. The potential for renewable energy generation (e.g. solar panels, dedicated wind turbines, ground source heat pumps or biomass boilers) to meet energy needs at the central office compound should be considered.

All buildings on site should be designed to meet or exceed future Building Standards; this might require achievement of a BREEAM rating of 'very good', with an aim to achieve 'excellent' where possible. They should be designed to the highest standards of energy and water efficiency, incorporating features such as energy efficient insulation materials, lighting and heating systems and appliances and should be well adapted to future climate. Designing in low carbon energy provision and energy efficiency is more cost effective than retrofitting solutions at a later date and is therefore recommended.

It is likely that future Building Standards would require the central office compound to operate in a manner that minimises net annual emissions as close to zero as possible, in line with the UK Government's projected 'zero carbon' building requirements. This could include consideration of site orientation to optimise solar gain, insulation, passive ventilation techniques, use of photo-voltaics or other sources of renewable energy for on site energy generation, and the potential for small scale Combined Heat and Power, as well as ensuring energy efficiency measures within all office equipment and fittings.

The consequences of climate change may be positively mitigated by avoiding situating the central office compound in a floodplain or other flood sensitive area and through the provision of appropriate drainage. Drainage on site should be sufficient to manage surface water flows and minimise risk of site flood during heavy rainfall. All infrastructure key to the site investigation works, such as power supply and computer systems should be designed to be fully resilient to flooding such that in the event of localised flooding, the works are not affected.

The potential risks of constructing and operating boreholes in a floodplain or flood sensitive area may be mitigated by avoiding construction (and where possible drilling) works during times when risk may be highest (fluvial flooding is considered to be greatest risk in winter in non-urban areas). The risks of tidal flooding would vary according to different influences such as tide times, and may occur at other times of the year. Drill pads located in such areas may further mitigate flooding by incorporating flood defences such as a surrounding bund and appropriate drainage measures.

Summary of information requirements: Subsequent assessments would require more information on the likely location of floodplains and flood sensitive areas. The likely consequences of climate change may then be identified.

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 9A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.



9. Climate Change

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 9A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- Increase in carbon dioxide emissions (due to the direct or indirect combustion of fossil fuel) during borehole construction associated with vehicle movements, use of diesel generators, and energy used in infrastructure (including the embodied energy within construction materials used).

It is assumed that the site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there is not considered to be any significant difference in potential effects.

10. Noise and Vibration

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: The use of explosives and vibroseis trucks for seismic surveys would generate noise and vibrations, although the vibrations would be of low amplitude and of short duration and therefore the effect would probably be negligible.

Deep borehole construction: There would be an increase in noise during the aerial surveys due to the low altitude of the aircraft (50-100m), although this would be for a very short duration and would only affect a localised area (where there may not be any sensitive receptors).

The construction of the drilling pads, support infrastructure and access roads during the borehole construction phase would result in perceptible increases in noise. Significant sources of noise include drilling rigs, diesel generators (if applicable), HGVs, delivery vehicles, vans and personnel vehicles. The principal source of noise is anticipated to occur would be from the drilling activities – both continuous background noise on a 24 hour basis and intermittent noise levels during pipe handling. Exploratory boring activities are likely to result in approximately 80dB LAeq at a distance of 10m.

Noise effects may also arise from works traffic (transport of materials, spoil and personnel to and from the sites). Assuming that traffic would have to use local roads (e.g. lower order, B and C roads) and may pass close to sensitive receptors, it is anticipated that there may be a negative noise effect from traffic, particularly HGVs, passing along non-primary routes. However, the exact route(s) would depend on the site(s) location and extent of local receptors, and would usually be decided in consultation with the Local Authority highways representative.

Activities associated with borehole construction, such as drilling and HGV movements, may also have vibration effects. Vibration effects from drilling would be difficult to quantify until such time as the ground conditions at the site are known, as the nature of the rock at the site needs to be confirmed to determine the level of propagation from the source, ideally through a blast test.

Depending on the proximity of sensitive receptors to the works locations, there would be the potential for noise and vibration associated with the borehole construction and continuous drilling works to have an effect on sensitive receptors (occupants of residential buildings, community and recreational facilities and noise sensitive businesses and enterprises). However, whilst activities on site would generate noise and vibration, any effects would probably not be significant due to the need to adhere to the requirements of legislation (Control of Pollution Act, 1974) and best practice set out in BS 5228:2009 (Code of Practice for Noise and Vibration Control on Construction and Open Sites). Good management of any works would ensure that a breach of limits would be unlikely.

Post-completion testing and baseline monitoring: There are unlikely to be any significant noise and vibration effects from the post-completion testing and baseline monitoring activities. There may be some noise from pump operation for hydrogeological testing, although this would be substantially less than during drilling.

At this stage no sites have been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the sites and surface-based site investigation works to sensitive receptors and the level and extent of noise and vibrations generated.



10. Noise and Vibration

A. Higher Strength Rock (cont)

Assumptions and uncertainties: It is assumed that the drilling phase of the activities is likely to have the greatest detrimental effect although it would depend on the proximity of sensitive receptors to the works locations. Consequently, at this stage there is a great deal of uncertainty. It is assumed that HGV traffic may have to use local roads (e.g. lower order, B and C roads) to reach the access roads to the drilling pads and may pass close to areas of sensitive receptors such as small urban areas, residential areas etc. However, the exact route would depend on the site(s) location and extent of local receptors.

It is assumed that the surfaced based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any significant differences in potential effect between the different waste inventories.

Proposed Mitigation/Enhancements:

Acceptable levels of noise and vibration at working sites should be defined in Tender documents and monitored constantly to ensure compliance.

Noise levels at the nearest receptors would need to be agreed with the Local Authority Environmental Health Officer or equivalent, and would typically be enforced through a Section 61 Agreement under the Control of Pollution Act, which would give prior consent to carry out certain construction works. Noise levels at the nearest receptor should go below minimum levels of 70 dB(A) at receptors in non-urban, industrial areas. Limits would typically be taken from BS 5228: 2009, which specifies a limit of 65dB(A) in quiet areas for airborne noise.

Some local authorities advocate noise limits given in Minerals Planning Statement 2 (MPS 2), Controlling and Mitigating the Environmental Effects of Mineral Extraction in England, with equivalents for the rest of the UK) as appropriate for construction projects, and given the nature and duration of the construction works this could be a reasonable requirement. MPS 2 allows for higher noise levels for short periods where working is close to receptors, typically for the construction of noise mitigation such as bunds or screening, but a lower long-term noise limit.

BS 5228: 2009 contains a large amount of good practice guidance which should be implemented by the contractor, with the aim of reducing any noise and vibration effects on receptors. The noisiest activities should be limited to daytime periods (including deliveries to site). Good practice measures that should be adopted include the use of acoustic screening to help to reduce off-site noise; selection of plant systems that generate minimum noise levels; enclosure of noisy plant and equipment within buildings or kiosks, if necessary fitted with acoustic panels; considered placement of equipment away from sensitive receptors; the use of padding between drilling pipes to reduce component movement; and use of 'quiet' (Smart) reversing alarms on vehicles. It is anticipated that with acoustic screening providing 10dB LAeq of attenuation, the noise level of drilling would be 40dB at 335m.

The appropriate amount of explosives to be used for seismic surveys and the detonation sequence should be calculated such that vibration levels are controlled to levels below the maximum permissible level.

The use of mains electricity supply in preference to a diesel generator may also help to minimise noise and emissions (refer to Sustainability Themes 8A and 9A).

Traffic movements should be controlled by traffic management measures specifying routes and times (such as restricting operating hours of large surface vehicles and restricting delivery times to the site) (refer to Sustainability Theme 7A).

Summary of information requirements: More information is required on the noise levels of the various equipment to be used and the location of site(s) so that a more detailed and accurate assessment of the effects may be made. In particular, further information should be sought to identify the effects of changes in noise and vibration levels on broad receptors (e.g. residential area).

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 10A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.



10. Noise and Vibration

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 10A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

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- Potential for noise disturbance from regional survey activities (aerial surveys and seismic surveys) and construction activities associated with the drilling campaigns (construction of borehole drilling pads, support infrastructure and access roads), including noise associated with traffic movements (particularly HGVs).
- Potential for noise disturbance from borehole drilling activities (both continuous background noise on a 24hr basis and intermittent noise during pipe handling).
- Potential for vibration effects from seismic surveys (vibroseis trucks) and borehole drilling activities.

At this stage no sites have been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the sites and surface-based site investigation works to sensitive receptors and the level and extent of noise and vibrations generated.

It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there is not considered to be any significant difference in potential effects.

11. Land Use

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: No effects on land use are anticipated as a result of the regional surveying activities.

Deep borehole construction: The drilling campaigns would involve land take; it is assumed for planning purposes that deep borehole construction would be undertaken within two areas, each of around 50km². Each area would potentially contain up to 16 deep borehole drilling pads, each with a footprint of approximately 0.01km² (a total land take of around 0.16km² of the total area for deep borehole drilling pads). Further land take within the area would also be required for the construction of access tracks and the central office compound, and for shallow borehole drilling campaigns. The remaining land within the area is assumed to remain in its existing use.

Assuming the land is greenfield, there would be the potential for the land take to have a negative effect throughout the duration of the deep borehole construction through to completion of post-completion testing, particularly where there may be a consequential loss or severance of agricultural land or community/recreational land.

Post-completion testing and baseline monitoring: No effects on land use would be anticipated as a result of the post-completion testing or baseline monitoring activities.

Following completion of the surface-based site investigations, where an area is not taken forward, assuming that the land would be restored to its pre-programme condition following the works (if not better than), it is deemed that the long-term effect on land use would be negligible. However, in the case of the area chosen to be taken forward, part of the area could be retained for construction of the GDF, in which case any effects from land take would remain.

Assumptions and uncertainties: It is assumed that the land take requirements are likely to be in greenfield locations. As such, depending on the grade of the agricultural land, good quality agricultural land (grade 1-3a) could be affected by the works.

There is uncertainty of the significance of the effect, until the location of the areas are known. The significance of the land take, particularly loss of agricultural land or community/recreational land would depend on the quality of agricultural land and the characteristics of the surrounding area (i.e. the extent of land of equal value in the surrounding area).



11. Land Use

A. Higher Strength Rock (cont)

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any significant differences in potential effects.

Proposed Mitigation/Enhancements:

The highest grade agricultural land should be avoided where possible and consultation should be undertaken with the landowners/tenant farmers as relevant in determining the location of drilling areas (particularly shallow boreholes) to minimise disruption to existing land uses.

The siting of the drilling pads should aim to minimise the need for additional access roads and the loss of noted landscape features or views (refer to Sustainability Theme 2A).

Office accommodation could be located on previously developed land or make use of existing accommodation through reuse and refurbishment to minimise land take.

Land use requirements should be carefully considered to strike a balance between minimisation of land take (and therefore effects on existing land use) and incorporation of suitable measures required for mitigation or enhancement, notably landscape screening and planting.

Where effects on an existing land use are unavoidable through siting or design, particularly where the site investigation works could affect the viability of a business for the period of the works programme, compensation or benefits should be provided as appropriate, either financially or through the provision of similar land or alternative premises elsewhere.

Should any public rights of way be affected as a result of the works, they should be diverted to allow their continued use wherever possible.

Following completion of the site investigation works, the land should be restored to its previous condition and, where possible, a more favourable condition.

Summary of information requirements: Further information is required on the locations. Details on the likely land take of road access would also be able to be determined at a later stage, which would help contribute to more detailed assessment at a later stage.

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 11A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 11A. Higher Strength Rocks), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- Potential for land take for site investigation works to have an effect on existing land uses, particularly where land take results in the loss or severance of agricultural land or community/recreational land.

- It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there is not considered to be any significant difference in potential effects.



12. Socio-economics

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: There are unlikely to be any significant socio-economic effects associated with regional surveying activities, as these activities would be limited in scale and duration, and would be undertaken by specialist contractors.

Deep borehole construction: The construction of the drilling pads, support infrastructure and access roads essentially comprises a civil engineering project to help set up the site for the investigation works. It is anticipated that the construction of the drilling pads may create employment opportunities for an estimated 10 unskilled/semi-skilled labourers for approximately 160 days over the 6 years at each site (assuming a 10 day construction period per drill pad, with up to 16 drill pads being constructed).

It is considered that a similar level of work, and employment, would be required to restore each site after the surface-based site investigation works have been completed. Although the majority of these job opportunities may be available to and taken by local contractors and individuals, this employment effect (the enabling of restoration works) whilst positive, would be unlikely to have a significant effect due to the scale and temporary nature of employment created.

For site investigation works, it is expected that specialist contractors would be employed with a range of associated on and off-site monitoring and assessment activities. It is understood that the central office compound would need to accommodate at least 150 people for the duration of these works and provides an indication of the scale of staff that may be employed for the duration of the borehole construction works.

Site based staff and visiting investigation contractors/analysts would introduce a demand for local accommodation and services. Given the duration of the works, there would be the potential that site based staff may relocate and become resident in an area for the duration of the works and, in addition to spending their money in the local economy, may bring families with children who may increase the demand for school places. Visiting staff would require accommodation in local hotels with requirements for different local services, for example taxis and restaurants. It should be noted that a local community in a greenfield/rural setting may be particularly sensitive to the demand created by such activities with potentially both significant positive and negative effects.

Depending on the location of the sites and the proximity of local populations, there may be a negative effect on quality of life from borehole construction activities (e.g. associated with the increase in traffic on the road network, noise, vibration and air quality effects from works and traffic), although it is deemed to be uncertain until the locations of the sites are identified. Potential receptors include neighbouring residents, schools and users of community, leisure and recreational facilities, public open space and rights of way.

There would also be the potential for drilling campaigns, given their duration, to affect the viability of businesses (e.g. effects on productivity due to disturbance to staff from noisy activities).

Post-completion testing and baseline monitoring: There would probably not be any significant socio-economic effects associated with post-completion testing or baseline monitoring activities, as these activities would be limited in scale and duration, and would be undertaken by specialist contractors.

In total, for the duration of the site investigation works it is estimated that, on average 570 people per year could be employed during the surface-based site investigations, of which an estimated 491 people would be directly involved in the surface-based site investigation works.

Assumptions and uncertainties: The significance of the social and economic effects of the proposed investigation works would be very dependent on the nature of the local economy and its sensitivity to the character of effects predicted. It is not possible to come up with a 'generic economic response' so, in the absence of any specific sites, the assessment considers the affect on a 'typical' greenfield/rural community rather than a more brownfield/urban setting.

At this stage no sites have been selected and subsequently the potential for effects on quality of life and business productivity is uncertain. The potential for effects would depend on the proximity of the sites and site investigation works to sensitive receptors and the level and extent of any disturbance.

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there is not considered to be any significant differences in potential effects between the different waste inventories.



12. Socio-economics

A. Higher Strength Rock (cont)

Proposed Mitigation/Enhancements:

Any opportunities to employ local contractors and individuals for site investigation works or for the use of local materials and suppliers should be identified, although due consideration and adherence to local employment legislation is required (e.g. no discrimination on any grounds). As such it may be difficult to offer employment opportunities exclusively to local people. Any potential to offer training opportunities (e.g. apprenticeship schemes) should be pursued.

Any increase in demand for services and accommodation arising from the site investigation works and its potential effect on the existing community should be considered carefully. Where possible, consideration should be given to opportunities for enhancement in the local area through the provision of improved or additional facilities or services, particularly where demand for such services would increase as a result of the works. Care should be taken to consider the effects and requirements of the community with respect to factors such as opportunities for access to services, facilities, leisure, recreation, education, training and housing.

It should be noted that the use of hotels/guesthouses could have a greater positive effect on the local economy, as a result of indirect and secondary effects, than renting houses for construction workers, which may increase the price for the local population.

Should borehole construction works affect public rights of way, these should be diverted to allow their continued use wherever possible. Similarly, effects on amenity value should be minimised as far as possible (refer to Sustainability Theme 2A).

Consideration should be given to opportunities for enhancement, such as improvements to the public rights of way network (e.g. in terms of usability, surfacing or routing).

Following completion of the works, consideration should be given to letting or selling the office accommodation as serviced office space, which may benefit firms in the area. Alternatively, the accommodation could be gifted to the local community and converted for community space.

Close consultation with the local community regarding potential improvements/enhancements is recommended to help ensure that local needs and wants are met.

Summary of information requirements: It is not possible to estimate the characteristics of these effects without more detailed information on the receiving environment. As such it is not possible to estimate the social and economic profile of a local area until a site(s) options comes forward. More information is required on the location of the site(s) and would enable a more accurate identification of effects in subsequent assessments. The opinions of local communities should also be sought when appropriate to identify appropriate guidelines defining behaviour for staff and contractors when in the local community.

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 12A. Higher Strength Rock), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 12A. Higher Strength Rock), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

+	<ul style="list-style-type: none"> - Potential for employment opportunities associated with surface-based site investigation works. - Potential for drilling campaigns to introduce a demand for local accommodation and services.
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12. Socio-economics

Headline Issues (cont)

?	<ul style="list-style-type: none"> - Potential for drilling campaigns to have a negative effect on quality of life and to affect the viability of businesses (e.g. associated with the increase in traffic on the road network, noise, vibration and air quality effects from works and traffic). <p>At this stage, no sites have been selected and subsequently the potential for effects on quality of life and business productivity is uncertain. The potential for effects would depend on the proximity of the sites and surface-based site investigation works to sensitive receptors and the level and extent of any disturbance.</p> <p>It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there is not considered to be any significant difference in potential effects.</p>
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13. Health and Well-being

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: There are unlikely to be any significant effects on health and well-being associated with regional surveying, as the activities would be limited in scale and duration. However, there may be some temporary noise disturbance to residents from aircraft during low level aerial surveys.

Deep borehole construction: Depending on the location of the sites and the proximity of local populations, borehole construction activities could have a negative effect on health and well-being (e.g. disturbance from noise and vibrations, and air quality effects from works and traffic). Potential receptors include on site staff and visitors, neighbouring residents, schools and users of community, leisure and recreational facilities, open space and rights of way.

Surface-based site investigation works, particularly the drilling campaigns, may be subject to protest action from opposition groups and local communities. This may potentially increase people's fear of crime through the fear of vandalism and an influx of a large number of people into a localised area. However, at this stage it is uncertain what extent there would be active opposition to the work.

Post-completion testing and baseline monitoring: There is unlikely to be any significant effects on health and well-being associated with post-completion testing or baseline monitoring activities, as these activities would be limited in scale and duration.

Assumptions and uncertainties: At this stage no sites have been selected and subsequently the potential effects on health and well-being is uncertain. The potential for surface-based site investigation works to affect health and well-being depends on the proximity of the sites and site investigation works to sensitive receptors and the extent of any disturbance.

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any significant differences in potential effects between the different waste inventories.

Proposed Mitigation/Enhancements:

Drilling rigs, support infrastructure and access roads should be sited as far as possible from site boundaries remote from potential sensitive receptors and any works that have the potential to have an effect on health and being (e.g. noisy and dust generating activities) should take place within enclosed area wherever possible.

Measures to control emissions of dust, vehicle emissions and other discharges from the sites, as well as noise and vibration levels should be implemented (refer to Sustainability themes 8A, 7A, 5A and 10A respectively).

Transport routing strategies should be implemented in order to avoid, as far as possible, sensitive receptors (refer to Sustainability Theme 7A).

Contractors registered with the Considerate Constructors Scheme should be employed for the site investigation works where possible, who commit to best practice construction methods.

The use of prescriptive guidelines for staff and contractor behaviour within nearby settlements should be considered in line with the opinions of local residents to minimise disruption and develop good working relationships through liaison.



13. Health and Well-being

A. Higher Strength Rock (cont)

Close consultation and full exchange of information with the local community, liaison with the local police and authorities and the use of appropriate on site security should minimise the risk of negative consequences of protest action, such as an increase in fear of crime. This may be achieved through the use of relevant community forums.

The following hierarchal approach to addressing hazards should be followed where possible – Eliminate hazards through design; where hazards cannot be designed out they should be isolated or protection to workers and the public should be provided; Where the hazard cannot be avoided by protection or isolation, it's effects should be mitigated through design, process changes and management control measures.

Summary of information requirements: Further information is required on the proximity of the sites to sensitive receptors to identify the likely effects in more detail.

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 13A. Higher Strength Rock), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 13A. Higher Strength Rock), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

?	<ul style="list-style-type: none"> - Potential for surface-based site investigations, particularly drilling campaigns, to have a negative effect on health and well-being (e.g. associated with the increase in traffic on the road network, noise, vibration and air quality effects from works and traffic). - Potential for surface-based site investigation works to be subject to protest action from opposition groups and local communities. <p>At this stage no sites have been selected and subsequently the potential for effects on health and well-being is uncertain. The potential for effects depends on the proximity of the sites and site investigation works to sensitive receptors and the extent of any disturbance. At this stage it is uncertain what extent there would be active opposition to the work.</p> <p>It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there is not considered to be any significant difference in potential effects.</p>
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14. Safety

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: The regional surveying activities are unlikely to present any significant hazards or issues of safety. Any risks associated with any seismic surveys (e.g. handling and detonating explosives and the use of vibroseis trucks) would be limited to contractors undertaking the activities, and would have been identified and managed through the contractor's compliance with health and safety legislation and risk management procedures. As such, the potential effect is not considered to be significant. There are unlikely to be any significant changes in the levels of health or safety of the local population as a result of the regional surveying activities.



14. Safety

A. Higher Strength Rock (cont)

Deep borehole construction: Borehole construction activities would pose a number of significant hazards to the on site workforce and visitors. Hazards include collision/impact hazards (e.g. involving plant/vehicles and personnel); exposure to substances hazardous to health (e.g. contact with cement and dusts); entrapment; electrical hazards (e.g. electrical shock from live cables); and occupational hazards such as working at height and manual handling. However, although there are many potential risks, any risks would have been identified and managed through the contractor(s) compliance with health and safety legislation and risk management procedures. As such, the potential effect is not considered to be significant.

The surface-based site investigations are unlikely to present a significant risk to the public (i.e. local communities) provided access to the work areas was restricted and the relevant health and safety procedures were in place. Any increase in traffic movements on the local road network could increase the risk of road traffic accidents. However, the increase in traffic would not be significant (refer to Sustainability Theme 7A).

Post-completion testing and baseline monitoring: There are unlikely to be any significant changes in the levels of health or safety of the local population as a result of the post-completion testing and baseline monitoring activities.

Assumptions and uncertainties: It is assumed that staff undertaking the works would not be subjected to any higher degree of risk than if they undertook such activities elsewhere, they would be professionally trained and understand the risks of the activities which they practice. It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any difference in potential effects.

Proposed Mitigation/Enhancements:

A focus on implementing a safety culture should be adopted to reduce the risks to construction workers and local communities. Relevant legislation (e.g. the Borehole Sites and Operations Regulations 1999 (COMAH)) and best practice guidance should be adhered to and requirements exceeded where possible. Full implementation of CDM Regulations should apply to all works irrespective of scale or duration.

Contractors registered with the Considerate Constructors Scheme should be employed for the site investigation works where possible, who commit to best practice construction methods. Appropriate contractors with a shared commitment to safety, compatible with the Nuclear Decommissioning Authority's (NDA's) own mission statement, could be identified during the tendering process by recognising staff safety experience, safety records and safety procedures through the weightings given to the tender evaluation process.

The design of the sites and activities should be reviewed by an independent examiner to ensure that hazards are appropriately addressed. Where required, detailed method statements from contractors along with proof of permits to work, safe systems of working and sufficiently suitably qualified and experienced personnel should be obtained before issuing a contract.

Site access should be restricted as appropriate and all personnel on site should be inducted or briefed, to wear appropriate Personal Protective Equipment and to be accompanied by another member of staff as necessary to help to reduce accidents. Third parties may be protected from any increase to the risk of health and safety through adequate protection around the sites to prevent the public from entering the area.

Measures to control emissions of dust, vehicle emissions and other discharges from the sites, as well as noise and vibration levels should be implemented (refer to Sustainability themes 8A, 7A, 5A and 10A respectively). Appropriate routing of traffic (refer to Sustainability Theme 7A) may help to reduce the risks of traffic accidents.

Summary of information requirements: Further information is required to identify the likely effects in more detail. In particular, the exposure of sensitive receptors to hazards associated with normal activities and accident/emergency situations should be considered.

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 14A. Higher Strength Rock), as the rock type would not affect the activities required for surface-based site investigations.

No effects in addition to those identified for the higher strength rock type are anticipated.



14. Safety

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 14A. Higher Strength Rock), as the rock type would not affect the activities required for surface-based site investigations. No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- Hazards and risks arising from site investigation works to site staff and visitors.
- Potential increased risk of road traffic accidents associated with any in traffic movements arising from site investigations.

However, although there are many potential risks associated with site investigations, it is assumed that any risks would have been identified and managed through the contractors(s) compliance with health and safety legislation and risk management procedures. Members of the public would not be allowed on site. As such, the potential effects are not considered to be significant.

It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there is not considered to be any significant difference in potential effects.

15. Waste

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: There would be a small arising of waste following the regional surveying activities, including shot hole spoil and explosives packaging. Due to the extent of the surveys, waste from these activities is deemed to be negligible.

Deep borehole construction: During borehole construction campaigns, waste would be generated in four forms including, soil drill cuttings, waste drilling fluid, saline water from testing and normal packaging/site wastes. If the wastes arising are averaged out as 20 boreholes of 25,000m of drilling over a 6 year period then the following wastes would be produced:

Drill cuttings 75 to 100m³/year;

Drilling fluid 250 to 300m³/year;

Test water 300 to 350m³/year; and

Construction waste 400 to 500m³ year.

It is also expected that there would be some increase in general office waste such as paper, organic canteen waste, packaging and possibly some electrical waste from the replacement and upgrades of computers, printers or other electrical products. The average annual waste figures for UK Government indicate that approximately 0.45 tonnes of waste are generated per employee per annum. Consequently, it is anticipated that some 67.5 tonnes may be generated by the office accommodation per year.

In addition, it is anticipated that there would be a small amount of waste generated during the drilling process from waste oil, greases and solvents for the machinery at each drilling pad, along with containers and packaging (timber pallets, casing thread protectors for drill components and excess cement from casing installations), from fuels, oils and cement.

Depending on their type, wastes may be sent to landfill, recycled or re-used, for example, as landscaping or as aggregates for construction projects. Drilling fluid is anticipated to be mechanically filtered and treated on site to remove sediment load. Depending on the fluid used, it may be recycled, discharged or removed for further off-site treatment. Some of the waste (some drilling fluid, small amounts of laboratory waste) may be treated as hazardous waste and would need to be handled in compliance with the relevant waste legislation.

Post-completion testing and baseline monitoring: It is anticipated that there would be an increase in waste generated during the testing stage such as laboratory sample containers (although most of these are likely to be re-used). However, some may be considered to be hazardous or special waste.



15. Waste

A. Higher Strength Rock (cont)

Assumptions and uncertainties: It is assumed that the waste generated by the drilling activities would be generated evenly over the course of the programme. It is likely that there would be peaks of waste generated during the construction phase of drilling pads which would require appropriate management. At this stage, it is uncertain how much waste may be re-used on site or recycled.

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any significant differences in potential effects.

Proposed Mitigation/Enhancements:

Best practice waste minimisation and management practices should be implemented, with a focus on materials resource efficiency (using less and re-using more), in accordance with WRAP guidance, Delivering Effective Waste Minimisation and Delivering Good Practice Waste Management.

Materials usage and waste should be considered early in the design process and opportunities to 'design out waste' should be considered. This could involve: design with existing resources (taking account of resources available on site or close by); standardisation of building form, layout and materials; design for easy demolition, re-construction and adaptability; designing to material dimensions; use of made-to-measure materials; and the use of modern methods of construction (that eliminate or reduce the requirement for site cutting and handling of materials). This should involve early discussions between the client, designers, contractors and subcontractors to identify potential waste streams and their quantities.

Where there is the potential for long-term use of buildings on the candidate sites (e.g. the offices within the central office compound), a high level of design quality and flexibility should be adopted to allow for future use. Further guidance on waste minimisation through design is provided in the WRAP document, Achieving Effective Waste Minimisation through Design: Guidance on designing out waste for construction clients, design teams and contractors.

Construction materials that are compatible with recycling or ease of re-use should be utilised where possible. Provision should be made for the segregation of wastes to enable a high level of recycling. Options for re-use of materials on site should be identified. Where re-use and recycling is not possible, options for disposal should be investigated to minimise environmental effects.

The use of products and materials with good practice levels of recycled content and inherently lower embedded carbon (relative to other products meeting the same specification), or those with low environmental impact (e.g. those that are A-rated in the Green Guide specification) should be specified. AggRegain, the free sustainable aggregates information service provided by the WRAP Aggregates Programme (<http://www.aggregain.org.uk/>), provides a lot of useful information and advice on sourcing sustainable aggregates.

Opportunities for the beneficial re-use of drilling cuttings should be explored (e.g. re-use of cuttings as a secondary aggregate). When considering the viability of any options, commercial, technical and environmental factors should be explored.

Best practice procedures for the protection, storage and handling of materials should be followed. A robust logistics plan should be developed, identifying how materials are to be moved to, from and on site and how they are stored. This could include just in time delivery or the use of consolidation centres to help reduce damage to materials and products by minimising the amount of time stored on site, and take back schemes for surplus material.

The potential for materials wastage should be reduced through effective procurement; producing accurate estimates of materials required, ordering the correct amount of materials at the correct time, developing partnerships with suppliers who can implement waste minimisation at source; and setting up schemes with suppliers to take back surplus materials.

A waste minimisation strategy should be implemented as part of the Site Waste Management Plan (SWMP) for the works. As a minimum, the SWMP should contain detailed measures to comply with relevant waste legislation but should also include good practice guidance and objectives in order to maximise the reduction, reuse and recovery of waste, with disposal to landfill as the least preferred option. The waste minimisation strategy should identify where waste arises in design, procurement and logistics and set out clear mechanisms for achieving waste reduction. Further guidance on site waste management is provided in the Department of Trade and Industry (DTI) document, Site Waste Management Plans, Guidance for Construction Contractors and Clients and supplementary guidance available from WRAP (www.wrap.org.uk/construction).



15. Waste

A. Higher Strength Rock (cont)

It is considered that the appointment of trained, experienced and professional contractors would also be beneficial to reducing construction waste generation as they may work more efficiently than those with less experience.

Training and educating site staff on how to reduce waste, and the appointment of contractors registered with the Considerate Constructors Scheme may also help to ensure the appropriate management of construction waste, who commit to best practice construction methods.

Summary of information requirements: Further information on the availability and capacity of waste management facilities in the vicinity of the site would be useful in identifying the best method of managing waste whilst minimising transportation through the utilisation of local facilities where possible.

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 15A. Higher Strength Rock), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 15A. Higher Strength Rock), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- Construction and general office waste arisings throughout the surface-based site investigations works, including some potentially hazardous or special waste material from contaminated materials or testing.

It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there is not considered to be any significant difference in potential effects.

16. Resource Use, Utilities and Services

A. Higher Strength Rock

Assessment of Effects:

Regional surveys: It is unlikely that there would be significant changes in the amount, or source of energy consumed as a result of the surveying activities. Similarly there would be negligible changes to the use of resources as a result of the activities.

Deep borehole construction: A range of construction materials and resources would be required for the drilling campaigns, in particular for the construction of the drilling pads, support infrastructure and access roads. Key utilities and services (electricity, water supplies and communication systems) would also be required during borehole construction.

Throughout the drilling campaigns there would be an increase in energy use associated with the operation of plant machinery and equipment; the operation of drilling rigs; lighting to allow safe working and for security purposes; and site buildings and infrastructure (heating, lighting, canteen facilities and electronics).

Diesel generators may be used as the primary source of electricity at the drilling pads if suitable mains connections do not exist, or the local mains supply is deemed to be unreliable.



16. Resource Use, Utilities and Services

A. Higher Strength Rock (cont)

Water would be required for use in borehole construction activities (e.g. for making up drilling fluid, cleaning machinery, dust suppression, drilling fluid, pressure testing and cooling equipment) and for domestic purposes such as drinking water, canteen use, toilet and washing facilities etc (refer to Sustainability Theme 5A). The anticipated increase in water used is estimated to be approximately 1,000m³ per borehole for the borehole drilling and 16 litres per employee per day. It is anticipated that the office accommodation would require water consumption of approximately 2,400l/day (assuming 150 people consuming 16l/employee/day), although it could be substantially more if there are more staff in the office at any one time. Sewerage systems for treatment of wastewater may also be required, depending on whether there is opportunity to connect to the existing network.

Post-completion testing: The pumping of groundwater could have an effect on water resources during post-completion testing.

Baseline monitoring: The baseline monitoring activities would not result in any significant changes in resource use.

The significance of effects is dependent to some extent on the location of the sites, which would in turn dictate the availability of resources, utilities and services, and the sourcing of specific materials and their transport distance.

Assumptions and uncertainties: It is uncertain how many people would be located and based in the office accommodation at the various stages throughout the programme. It is assumed that there would be at least 150 staff located at the office.

It is assumed that the surface-based site investigation works for the Derived Inventory Reference Case excluding Pu/U would be broadly similar to those for the Derived Inventory Upper Inventory and therefore there would not be any difference in potential effects.

Proposed Mitigation/Enhancements:

Consideration should be given to sources of energy, utilities and services such that the effect of increased demand on existing services is taken into account.

Best practice waste minimisation and management practices should be implemented, with a focus on materials resource efficiency (using less and re-using more), in accordance with WRAP guidance, Delivering Effective Waste Minimisation and Delivering Good Practice Waste Management (refer to Sustainability Theme 15A). Measures to reduce resource use and encourage resource efficiency throughout the works should be outlined within the Environmental Management Plan for the site.

Where possible the use of mains electricity would be preferential to diesel generation, reducing fossil fuel use, noise and pollution in the vicinity of the works and therefore benefiting local communities and the environment. The potential for renewable energy generation (e.g. solar panels, dedicated wind turbines, ground source heat pumps or biomass boilers) to meet energy needs on site should be considered.

There is the potential for consideration to be given to the central office compound site becoming carbon neutral once operational. This could include consideration of site orientation to optimise solar gain, insulation, passive ventilation techniques, use of photo-voltaics or other sources of on site renewable energy generation, potential for small scale Combined Heat and Power (CHP) as well as ensuring energy efficiency measures within all office equipment and fittings.

All buildings on site should be designed to meet or exceed future Building Standards requirements. All buildings should be designed to the highest standards of energy and water efficiency, incorporating features such as energy efficient insulation materials, lighting and heating systems and appliances (e.g. double glazing, energy efficient bulbs, 'A' rated white goods and dual low flush toilets) and systems for the collection and recycling of water (e.g. rain water and grey water recycling systems).

Efficient use of materials should be promoted through effective procurement, providing accurate estimates of materials required, ordering the correct amount of materials at the correct time, and using supplies that take back surplus material.

As noted in Sustainability Theme 7A (Traffic and Transport), where practicable, consideration should be given to the use of more sustainable modes of transport such as rail. Measures to reduce private vehicle use and transport distances should also be implemented.

All available transport options should be subject to environmental assessment to determine their effect.

Summary of information requirements: Further information on the receiving environment would help inform the assessment and enable for a more detailed identification of effects. Of particular use would be to gain an understanding of the existing availability of utilities and resources (e.g. water resources in the region, energy resources in the region, the availability of waste management facilities etc).



16. Resource Use, Utilities and Services

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 16A. Higher Strength Rock), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 16A. Higher Strength Rock), as the rock type would not affect the surface-based site investigation activities required.

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- Increase in resource use, utilities and services during the surface-based site investigations, particularly during borehole construction.

It is assumed that the surface-based site investigation works would be broadly similar for the different waste inventories and host rock types, and therefore there is not considered to be any significant difference in potential effects.



Appraisal of the construction phase

Illustrative geological disposal concepts are being developed as “co-located” facilities for Low Level Waste (LLW), Intermediate Level Waste (ILW), and High Level Waste (HLW), and other radioactive materials: Plutonium (Pu), Uranium (U) and Spent Fuel (SF), which may be declared as a waste in the future. In a co-located facility there would be two distinct excavated disposal areas, separated by an appropriate distance, one for ILW, LLW and U residues, and the other for HLW, SF, Pu and highly enriched uranium (HEU). This is in line with the statement made in paragraph 4.25 of the Managing Radioactive Waste Safely (MRWS) White Paper that “*in principle the UK Government sees no case for having separate facilities if one facility can be developed to provide suitable, safe containment*”. However, as stated in the MRWS White Paper, “*the final decision would be made in the light of the latest technical and scientific information, international best practice and site-specific environmental, social, economic and safety and security assessments*”, so the possibility that more than one facility would be needed is recognised.^[4]

For the purposes of the generic assessment it has been assumed that a Geological Disposal Facility (GDF) would be a stand alone facility, with underground areas being accessed from a single surface site designed to accept, transfer and transport radioactive waste. The GDF would consist of surface buildings and infrastructure, an access road, rail infrastructure, underground accesses (a drift and/or several shafts) and, as noted above, separate waste disposal areas for ILW/LLW and HLW/SF connected by roadways and service tunnels. A summary of the main elements and design assumptions for the illustrative geological disposal concepts for each host rock type is provided below.

Higher strength rock

The host geology is assumed to be in a higher strength rock comprising crystalline igneous and metamorphic rocks or geologically older sedimentary rocks where any fluid movement is predominantly through discontinuities, overlain by a variable sequence of sedimentary strata. The following assumptions have also been made in order to develop illustrative geological disposal concept designs.

It is assumed that a GDF would be constructed on a single level at a depth of 650m. Underground facilities would be excavated by drill and blast methods and tunnel support would be by rock bolt, mesh and shotcrete.

Initial construction would take place over a period of some 10 years, during which time all three shafts and the drift would be constructed. Thereafter ILW/LLW vaults and HLW/SF disposal tunnels would be constructed as required (refer to the operational phase).

The main elements and assumptions for the higher strength rock type are:

Surface facilities: comprising construction support, operational management and administration, workshops and transport related infrastructure for receipt of radioactive waste by rail and/or road.



Underground access: the facility is to be accessed by one drift (sloping tunnel) and three shafts (vertical). The drift would be constructed at a gradient of 1 in 6 and would be around 4km in length. The drift would be 5.5m in diameter for the first 1.8km, then 'D' shaped (5.5m high x 5m wide) to the facility horizon. A hydrostatic lining is assumed for the first 300m depth of the drift. The drift would allow for radioactive waste to be transported underground and would also provide ventilation (along with the third shaft).

- The first and second shafts would be used for construction and to develop the underground infrastructure. The third shaft would be used for ventilation. The access and infrastructure are laid out to provide separate accesses for construction and disposal activities and provide independent ventilation circuits for both activities.
- **Common services area:** the main elements of the underground infrastructure are the ventilation hall, spoil bunker, workshops, battery charging area, personnel hall and the electrical hall.
- **ILW/LLW disposal area:** comprising a series of vaults connected by tunnels and a transfer system. ILW/LLW vaults would have an assumed support requirement of rock bolts and a lining of sprayed concrete to provide shielding.
- **HLW/SF disposal areas:** comprising a series of disposal tunnels connected by transport tunnels and a transfer system.

Lower strength sedimentary rock

The host geology is assumed to be a lower strength sedimentary rock comprising geologically younger argillaceous sedimentary rocks (rocks with a high clay content) where any fluid movement is predominantly through the rock matrix, overlain by a variable sequence of sedimentary strata. The following assumptions have also been made in order to develop illustrative geological disposal concept designs.

It is assumed that a GDF would be constructed on a single level at a depth of 500m. Underground facilities would be excavated by a combination of tunnel boring machine, road header and drill and blast methods. Tunnel support would be by rock bolt, mesh and shotcrete.

It is estimated that initial facility construction would take place over a period of some 10 years, during which time all three shafts and the drift would be constructed as well as the first ILW and LLW vaults. Thereafter ILW/LLW vaults and HLW/SF disposal tunnels would be constructed as required (refer to the operational phase).

The main elements and assumptions for lower strength sedimentary rock type are:

- **Surface facilities:** for construction support, operational management and administration, workshops and transport related infrastructure for receipt of radioactive waste by rail and/or road.
- **Underground access:** the facility is to be accessed by one drift (inclined tunnel) and three shafts (vertical). The drift would be constructed at a gradient of 1 in 6 and would be 3km long. The drift would be 5.5m in diameter for its full length. A hydrostatic lining is assumed for the first 300m depth of the drift.



The first and second shafts would be used for construction. The third shaft would be used for ventilation. The access and infrastructure are laid out to provide separate accesses for construction and disposal activities and provide independent ventilation circuits for both activities.

- **Common services area:** the main elements of the underground infrastructure are the ventilation hall, spoil bunker, workshops, battery charging area, personnel hall and the electrical hall.
- **ILW/LLW disposal area:** comprising a series of vaults connected by tunnels and a transfer system. ILW/LLW vaults would have an assumed support requirement of rock bolts and a lining of sprayed concrete.
- **HLW/SF disposal areas:** comprising a series of disposal tunnels connected by transport tunnels and a transfer system.

Evaporite rock

For the evaporite rock type the host geology is assumed to comprise anhydrite (anhydrous calcium sulphate), halite (rock salt) or other evaporites that result from the evaporation of water from waterbodies containing dissolved salts, overlain by a variable sequence of sedimentary strata. The following assumptions have also been made in order to develop illustrative geological disposal concept designs.

It is assumed that a GDF would be constructed on a single level at a depth of 650m. Underground facilities would be excavated by continuous miner and/or road header machines. Tunnel support would be by rock bolt and mesh.

Initial construction would take place over a period of some 10 years, during which time all four shafts would be constructed as well as the first ILW/LLW vaults. Thereafter ILW/LLW vaults and HLW/SF disposal tunnels would be constructed as required (refer to the operational phase).

The main elements and assumptions for the evaporite rock type are:

- **Surface facilities:** for construction support, operational management and administration, workshops and transport related infrastructure for receipt of radioactive waste by rail and/or road.
- **Underground access:** the facility is to be accessed by four shafts. Permanent support would be provided by concrete hydrostatic lining where necessary to prevent the ingress of water and a nominal concrete lining and/or steel mesh and rock bolting, where a hydrostatic lining is not required.
- The first and second shafts would be used for vault and disposal tunnel construction and the development of the underground infrastructure. The third shaft would be used for the transport of waste and would provide a separate ventilation circuit for disposal operations in shaft four. The access and infrastructure would be laid out to provide separate accesses for construction and disposal activities and provide independent ventilation circuits for both activities.
- **Common services area:** the main elements of the underground infrastructure are the ventilation hall, spoil bunker, workshops, battery charging area, personnel hall and the electrical hall.



- **ILW/LLW disposal areas:** comprising a series of vaults connected by tunnels and a transfer system. ILW/LLW vaults would have an assumed support requirement of rock bolts and mesh.
- **HLW/SF disposal areas:** comprising a series of disposal tunnels connected by transport tunnels and a transfer system.



Table D2 Appraisal of the construction phase

1. Policies and Planning

A. Higher Strength Rock

Assessment of Effects:

A GDF would fulfil a number of policy and legislative commitments at international and national level; according with the principles of the International Atomic Energy Agency Action Plan and the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, and meeting UK Government requirements for the long-term management of radioactive wastes in accordance with the MRWS Programme.

However, it is acknowledged that the construction of a GDF could be associated with a significant carbon footprint, which if not matched by corresponding reductions elsewhere in the UK economy could detract from the UK to meeting its obligations under the Climate Change Act 2008 (refer to Sustainability Theme 9A).

It is assumed that a GDF would be constructed on a greenfield site. It is noted that UK Government policy aims to focus new development towards previously developed sites where appropriate. Although siting a GDF on a greenfield site would not contribute towards fulfilling national policy, it is assumed that a greenfield site would only be brought forward for development if it was deemed the most appropriate location for the safe disposal of waste. Vacant brownfield sites may not be appropriate for a GDF given the likely proximity of such sites to existing communities. Notwithstanding this, it is assumed that at the site assessment stage no potentially suitable brownfield sites would be excluded.

The effect of the Derived Inventory Reference Case excluding Pu/U on policy requirements would be the same as those identified for the Derived Inventory Upper Inventory.

Assumptions and uncertainties: The construction phase would be the next stage in fulfilling policy and legislative commitments for the long-term management of radioactive wastes and is therefore assumed to have a positive effect.

Proposed Mitigation/Enhancements: All construction activities should adhere to relevant legislation and best practice guidance. Where possible minimum requirements should be exceeded as should any planning conditions relating to planning permission for the works.

Summary of information requirements: Once a preferred site has been chosen, relevant local planning policies (e.g. within the relevant Local Development Framework or equivalent) should be identified. The effects of a GDF in relation to these policies would require assessment following site selection, and activities amended where necessary to ensure that policies are adhered to.

B. Lower Strength Sedimentary Rock

The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 1A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 1A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

+	<ul style="list-style-type: none"> - A GDF would support UK Government commitments for the long-term management of radioactive wastes in accordance with the MRWS Programme. There would not be any significant differences between the different host rock types and waste inventories, as all of the proposed host rock types would meet policy requirements.
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2. Landscape and Visual

A. Higher Strength Rock

Assessment of Effects:

For the higher strength rock type, the surface site area is assumed to be approximately 1.1km² for both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory. Within this site area, the surface facilities and infrastructure would be constructed (construction support, operational management and administration, workshops and transport related infrastructure). Excavated rock would also be stored within the surface site area arising from the construction of the underground facilities. It is assumed that a capacity of up to 3,589,000m³ would be stored in bunds for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory. The landscape significance of such additional features would be dependent on the surrounding landscape character and the extent to which the spoil can be sympathetically contoured and re-vegetated.

There would be the potential for surface construction activities to have significant negative landscape and visual effects where activities result in the fragmentation or loss of key landscape elements or features, or where the introduction of the surface facilities and infrastructure and surface bunding significantly alters the landscape character. Construction activities may have a detrimental effect on landscape character due to the introduction of new visual elements (construction compounds and offices; construction machinery, particularly drilling rigs and cranes; spoil; hardstanding; and access roads), which may (depending on the exact location) contrast with the existing landscape. Effects on landscape character could be direct (where a site is located within a designated area of landscape value), or indirect (where the setting of the surrounding landscape is affected). Construction activities may also have a negative visual effect through the introduction of new elements into existing views or the loss of views (e.g. where the diversion of a right of way or right of access prevents the receptor from seeing the view).

Lighting would be required throughout the construction phase (machinery, office/facilities and security lighting), resulting in light pollution. Although most construction works would be limited to agreed hours, it is likely that some lighting for security purposes would continue to be in use throughout the night, although shielded to reduce light pollution.

There may be a need to construct new rail infrastructure to the site, or undertake improvements to the existing rail network. Similarly, to support Heavy Goods Vehicle (HGV) traffic to the site, improvements may need to be made to the local road network. These works may have a negative effect on the local landscape character of along existing or proposed transport corridors where there is any fragmentation or loss of key landscape elements or features or where works significantly alter landscape character. The removal of boundary vegetation (e.g. hedgerows, grass verges etc) may increase the visibility of existing landscape features as well as proposed new landscape features (e.g. existing roads and settlements). Increases in construction traffic on local road networks may also affect the tranquillity of these areas.

There would be the potential for any surplus excavated rock removed off-site from the construction of the underground facilities to have a negative landscape and visual effect. However, this would depend on its end use and location, and therefore the potential for effects is uncertain at this stage.

Assumptions and uncertainties: It is assumed for the purposes of this assessment that the site would be greenfield. The surface site area and the scale of surface development is assumed to be the same for the different waste inventories. It is assumed that construction material and construction wastes (with the exception of excavated rock) would be transported to and from the site via road. All surplus rock excavated from the construction of the underground facilities is assumed to be transported off-site via rail.

As a site has not been selected at this stage, the extent of any landscape and visual effects associated with the construction of a GDF is uncertain. This would be dependant on the scale and nature of the development, the surrounding landscape and topography, degree of urbanisation and extent of screening. However, there could be scope for micro-siting to reduce any potential effects from surface facilities and infrastructure and surface bunds, and creating opportunities to retain existing landscape elements within the site. It is also considered that the overall visual effect of the construction site could reduce as the construction programme progresses, as surface construction is completed and construction activities progress further underground, and potentially following the establishment of surface bunds around the site, which should reduce visibility into the site. Although it should be noted that, depending on their scale and nature surface bunds could also have a negative a landscape and visual effect (i.e. where the surface bunds are extensive and may not be well integrated with the landscape surrounding the site).

It is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore there would probably not be any difference in potential landscape and visual effects associated with construction between the different waste inventories.



2. Landscape and Visual

A. Higher Strength Rock (cont)

Proposed Mitigation/Enhancements:

At an early stage following site selection and prior to any construction works, a desk study and site walkover should be undertaken to determine the landscape character and quality of the site and its surrounds. Consideration should be given to the receiving environment and sensitivity of receptors and the potential effects on key views and designated landscape areas. In addition, effects on local landscape features, elements, character and quality and locally designated and undesignated areas of landscape value together with effects on local views should be considered. This would enable appropriate mitigation measures to be designed and implemented to have maximum impact in terms of reducing any negative effects.

Within the constraints of the host rock, the footprint of surface facilities and infrastructure should be minimised as far as practically possible, and surface infrastructure and facilities appropriately sited to reduce any landscape and visual effect.

Any loss of existing landscape elements such as woodland, trees, hedgerows and other planting within the site should be avoided where possible. Where vegetation within the site is of value, it should be retained where possible.

Temporary screens should be put in place prior to any construction works commencing, which can be replaced with surface bunds around the site as rock spoil from the excavation works becomes available.

Where possible, any landscape planting should be carried out at an early stage to allow the development of vegetation to help filter views of the surface works prior to commencement of construction work on site. Any planting undertaken on or off-site should make use of locally native tree and shrub species. Dependent on its location, large belts or blocks of planting may not be characteristic of the landscape surrounding the site.

Negative effects from the introduction of new visual elements may be reduced by the use of appropriate siting and screening of the construction plant and roads (through the use of existing woodlands or copses, landscaped and planted earth mounds, using excavated spoil and suitable grass seed mixes, or appropriate native planting. Any spoil mounds, surface bunds and planting should be of a scale that is characteristic of the local landscape (e.g. in terms of topography and vegetation).

In order to establish vegetation on surface bunds, it would be necessary to provide some form of growing medium over the piles of rock fragments to support plant growth. This would require consideration of the likely availability of soils from the excavation activities or elsewhere. Emerging research from WRAP identifies a method of producing topsoil from a mixture of waste aggregate and compost. This method also provides a means of recycling aggregates removed from the site (http://www.wrap.org.uk/downloads/Soil_Matters.7723a430.7363.pdf).

Buildings and infrastructure, including any temporary structures and compounds should be of a high quality design with due consideration given to the aesthetics in relation to existing local colours and architectural styles. The size of buildings should be kept to a practical minimum.

The colour and texture of surfaces should be considered and attempts should be made to minimise contrast with the landscape. Visual intrusion may be mitigated through the use of appropriate hardstanding materials (e.g. local crushed stone).

The use of fluorescent lighting should be minimised where possible to prevent overspill, glare and light pollution. The number and height of lighting poles should be reduced to a practicable minimum and directional shields used to control light spillage.

Summary of information requirements: Following site selection, information on the receiving environment and sensitivity of receptors needs to be obtained through a desk top study and site visit in order to determine the landscape character and quality of the site and its surrounds (refer to the proposed mitigation). Such information would enable any potential effects and appropriate mitigation measures to be identified.

B. Lower Strength Sedimentary Rock

The potential landscape and visual effects and mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer 2A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type has been identified.

Similar to the higher strength rock type, the surface site area for the lower strength sedimentary rock type would be approximately 1.1km². The surface site area would include surface facilities and infrastructure and up to 3,589,000m³ of excavated rock in bunds (for both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory).



2. Landscape and Visual

C. Evaporite Rock

The potential landscape and visual effects that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 2A. Higher Strength Rock).

Similar to the higher strength rock type, the surface site area for the evaporite rock type would be approximately 1.1km², assuming that the surface site area includes surface facilities and infrastructure and surface screening bunds. In the case of the evaporite rock type none of the excavated rock would be stored in surface bunds within the site, as the excavated evaporite rock would not be suitable for this. Instead the only excavated rock to be retained on site would be that required for backfilling of the HLW/SF disposal tunnels, shafts and common services area (estimated to be approximately 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory), which would be stored within a suitably designed area. Surface screening bunds would be created using spoil and imported material as required.

Although the surface site area is assumed to be 1.1km², given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types (which propose approximately 3,589,000m³ in bunds on the site), there is the possibility that surface disturbance could be less for the evaporite rock type.

Headline Issues

- The potential for surface construction activities to result in the loss of key landscape elements or features or to significantly alter landscape character, particularly the construction of the surface facilities, and the storage of excavated rock on site, either in surface bunds or within a dedicated storage area.
- The potential for surface construction activities to have a negative visual effect through the introduction of new elements into existing views or the loss of views, particularly from the introduction of surface bunds and from lighting on site.

There would probably not be any significant difference in potential landscape and visual effects between the different waste inventories and host rock types, as the surface site area is assumed to be the same (approximately 1.1km² for each of the host rock types, assuming that the surface site area for the evaporite rock type includes surface screening bunds).

Notwithstanding this, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type.

The potential landscape and visual effect of the construction of a GDF would be greater than that of the surface-based site investigations phase. However, at this stage no site has been selected and therefore the significance of any negative effects is currently unknown.

3. Cultural Heritage

A. Higher Strength Rock

Assessment of Effects:

Construction activities, in particular construction of the surface facilities and infrastructure could result in the direct loss of or damage to visible above ground cultural heritage or archaeological features within the development footprint of the surface site area (assumed to be approximately 1.1km², including surface facilities and infrastructure, and up to 3,589,000m³ of excavated rock stored in bunds). Construction activities may also have a negative effect on the setting and amenity of above ground historic or archaeological features and landscapes (e.g. world heritage sites, conservation areas, listed buildings, scheduled monuments and registered parks and gardens) within the vicinity.

Construction activities (e.g. stripping topsoil, site levelling, digging foundations, piling works, drilling and excavations) have the potential to result in the direct loss of or cause damage to subsurface or buried archaeological remains. This may include known archaeology (such as designated or recorded sites) or previously unknown archaeology.



3. Cultural Heritage

A. Higher Strength Rock (cont)

Generally, there would be limited potential for archaeology below a depth of 1-2m (with the exception of historic mine workings), with any remains typically found within the soils above the drift geology. The greatest potential for effects on subsurface or buried archaeological remains is therefore during construction of the surface facilities and infrastructure, and excavations into the soils above the drift geology. Excavation activities at a depth of greater than 2m are unlikely to affect subsurface or buried archaeological remains and there would be limited potential for archaeological remains within the host rock (assuming there are no historic mine workings). However, it is also recognised that there would be the potential for any additional discoveries to be made during construction activities.

There would be the potential for indirect damage to subsurface or buried archaeological remains due to contamination, ground consolidation, or changes to the hydrological regime. However, as noted above there would be limited potential for archaeology within the host rock, and the potential for significant ingress is considered to be low.

The extensive ground and aerial surveys undertaken as part of the surface-based site investigations work may have identified the location of any archaeology. Although as the geophysical 2D seismic survey is to be undertaken at a district level, approximately 600km², there would be a significant chance that it may miss local archaeological features.

There would be the potential for pollution from engine exhausts and vibration associated with any increase in rail traffic or road traffic (particularly HGVs in the case of road traffic) over the construction period (refer to Sustainability Theme 7A) to have a negative effect on historic or archaeological features (e.g. listed buildings) by accelerating corrosion.

It is unlikely that there would be any significant effects on traditional activities in the area (e.g. farming) unless the construction of a GDF results in the loss or fragmentation of land used for such activities.

Assumptions and uncertainties: It is assumed for the purposes of this assessment that the site would be greenfield. The surface site area and the scale of surface development is assumed to be the same for the different waste inventories. It is assumed that construction materials, machinery and construction waste (with the exception of excavated rock) would be transported to and from the site via road. All of the surplus rock excavated from the construction of the underground facilities is assumed to be removed off-site via rail.

At this stage no site has been selected and subsequently the effect of the construction of a GDF on cultural heritage and archaeology is uncertain. The scale of any effect would depend on the proximity of construction activities to any cultural heritage and archaeological sites and features and their settings, the condition and sensitivity of the site/feature/setting affected and the level of disturbance or loss.

It is assumed that the footprint of surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore there would probably not be any difference in potential cultural heritage effects associated with surface construction activities between the different waste inventories.

Similarly, the potential effects of excavation activities associated with the construction of the underground infrastructure on subsurface or buried archaeological remains would be similar for both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory as the level of disturbance to the soils above the drift geology is assumed to be similar.

Proposed Mitigation/Enhancements:

It is anticipated that any significant detrimental effects arising from the construction of a GDF on cultural heritage and archaeology, including subsurface and buried archaeology and traditional activities may be minimised through early liaison with, and adhering to guidance issued by English Heritage, the National Trust and other appropriate organisations.

At an early stage following site selection and prior to any works on site, a desk study and site walkover should be undertaken to determine the historic and archaeological value of the site in consultation with English Heritage, the relevant local authority heritage officer and other relevant bodies (it is expected that a desk study and walkover would have been undertaken as part of the surface-based site investigation works, which could be revised and updated as necessary for the construction phase). The desk study and site walkover would identify the need for further site evaluation (i.e. hedgerow surveys; field surface collection; monitoring and assessment of geotechnical work including a watching brief on geotechnical test pits; geophysical survey; trial trenching; and other specialist surveys).

In addition to the assessment of effects on archaeological and built heritage features, the effect on historic landscapes should also be considered. This should include characterisation of the landscape and effects on any contribution that the heritage resource may make to tourism in the area.



3. Cultural Heritage

A. Higher Strength Rock (cont)

Where there is the potential for adverse effects on cultural heritage and archaeology, surface infrastructure and facilities and excavated rock spoil should be appropriately sited to reduce any negative effects and the development footprint minimised as far as practically possible. This would also help to reduce landscape and visual effects of the facility (refer to Sustainability Theme 2A). Refer to the landscape and visual mitigation identified in Sustainability Theme 2A for further mitigation that could reduce potential effects on the setting and amenity of above ground historic or archaeological features and landscapes.

Further mitigation might include alterations to the construction methodology (e.g. foundation design and excavation methods) in order to minimise effects or the retention of historic or archaeological features in situ. The potential for contamination can be minimised by following best practice pollution prevention methods, ground movement can be minimised by ensuring appropriate site selection through geotechnical mapping, and groundwater control techniques can be utilised to preclude or minimise ingress.

If retention of any features is not possible, consideration should be given to moving features to another location or storage, or a detailed excavation and recording of the affected feature should be undertaken. A watching brief is recommended during topsoil stripping and excavation in order to identify any unexpected features or artefacts arising during construction. If any archaeological features or artefacts are discovered, this may also require a temporary suspension of any intrusive activities in the affected area of the site.

Identifying appropriate routes to access the site would help to minimise potential negative effects on historic or archaeological features (e.g. listed buildings) caused by transport pollution and vibration.

Summary of information requirements: Site-specific information is required to establish the likelihood of any effects on above ground cultural heritage or archaeological features and their settings, and the likelihood of encountering archaeological remains (refer to the desk study and site walkover mitigation).

B. Lower Strength Sedimentary Rock

The potential effects of the lower strength sedimentary rock type on cultural heritage and archaeology that could occur, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 3A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type has been identified.

Similar to the higher strength rock type, the surface site area for the lower strength sedimentary rock type is assumed to be approximately 1.1km², including surface facilities and infrastructure and up to 3,589,000m³ of excavated rock stored in bunds.

C. Evaporite Rock

The potential effects of the evaporite rock type on cultural heritage and archaeology that could occur, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 3A. Higher Strength Rock).

Similar to the higher strength rock type, the surface site area for the evaporite rock type is assumed to be approximately 1.1km². However, for the evaporite rock type the surface site area would include surface facilities and infrastructure, a dedicated storage area for excavated rock (approximately 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) and surface screening bunds.

Notwithstanding this, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types (approximately 3,589,000m³ in bunds on the site for the higher and lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type.

Headline Issues

?	<ul style="list-style-type: none"> - Potential for surface construction activities to result in the direct loss of or damage to visible above ground cultural historic or archaeological features (including landscape features such as hedgerows). - Potential for construction activities to result in the direct loss of or cause damage to subsurface or buried archaeological remains (known archaeology such as designated or recorded sites, or previously unknown archaeology).
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3. Cultural Heritage

Headline Issues (cont)

- Potential for surface construction activities to have a negative effect on the setting and amenity of above ground historic or archaeological features and landscapes.
- Potential for pollution and vibrations associated with rail or road traffic to have a negative effect on historic or archaeological features.

There would probably not be any significant difference in potential effects on visible above ground cultural heritage or archaeological features between the different waste inventories and host rock types, as the surface site area is assumed to be the same (approximately 1.1km², assuming that the surface site area for the evaporite rock type includes surface screening bunds).

Notwithstanding this, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type.

There would probably not be any significant difference in potential effects on subsurface or buried archaeological remains between the different host rock types, as excavation activities at a depth greater than 2m would be unlikely to affect subsurface or buried archaeological remains (assuming there are no historic mine workings).

At this stage no sites have been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the works to any cultural heritage and archaeological sites, features and landscapes, the condition and sensitivity of the site/feature/landscape affected and the level of disturbance or loss.

4. Geology and Soils

A. Higher Strength Rock

Assessment of Effects:

The construction of a GDF would initially involve site clearance and levelling. In doing so there would be a loss of soil and sedimentary rock within the footprint of surface facilities/infrastructure (buildings, hardstanding and access roads). For the higher strength rock type the surface site area is assumed to be approximately 1.1km². The topography of the site would determine the degree to which the site would need to be levelled and the subsequent amount of spoil arising. It is likely that any soil may be used for landscaping (surface bunds) around the site.

At this stage it has been assumed that a GDF would be located on a greenfield site and therefore it would be unlikely that any ground contamination from previous land uses would be encountered. Given the timescales and scale of works, it would be likely that a number of construction activities (e.g. drilling) could introduce levels of contamination (including, for example, silty water, drill fluid and oil spillages). It would be expected that any potential contamination would be sufficiently mitigated by following best practice guidance. However, it would not allow for accidental or unforeseen discharges.

The construction of a GDF would require large volumes of rock to be excavated: approximately 5,225,000m³ for the Derived Inventory Reference Case excluding Pu/U and 13,800,000m³ for the Derived Inventory Upper Inventory.

For the higher strength rock type it is proposed that up to 3,589,000m³ of the excavated rock would be used to construct surface bunds within the surface site area. In addition, 1,190,000m³ of excavated rock for the Derived Inventory Reference Case excluding Pu/U, and 3,010,000m³ of excavated rock for the Derived Inventory Upper Inventory, would be used as backfill material for backfilling the HLW/SF disposal tunnels (which would take place during the operational phase). For both waste inventories, a further 263,771m³ and 296,308m³ is also estimated to be required for the backfilling of the drift and shafts, and common services area respectively (which would take place during the closure phase). In the case of the Derived Inventory Reference Case excluding Pu/U, all of the higher strength rock excavated would be utilised on site and therefore no excavated rock would need to be taken off-site. For the Derived Inventory Upper Inventory, not all of the excavated rock would be utilised on site. The surplus excavated rock, estimated to be 6,640,921m³ for the Derived Inventory Upper Inventory, would be taken off-site.



4. Geology and Soils

A. Higher Strength Rock (cont)

Given the footprint of the underground facility and the volume of rock excavated, there would be the potential for the construction of the facility to affect sites of recognised importance for their geological value (e.g. Sites of Special Scientific Interest (SSSI) or Regionally Important Geological Sites (RIGS)), although the designation is typically determined by the surface geology rather than the deeper stratigraphy. Such effects would be site specific and therefore the potential effect on sites of geological value is uncertain at this stage.

Similarly, there would be the potential for the construction of the facility within higher strength rock to result in the loss or sterilisation of a minerals resource, or a minerals reserve (where a site is covered by valid planning permissions for the extraction of minerals). Sterilisation occurs when other non-minerals development takes place on, or close to, minerals deposits, rendering them incapable of being extracted. However, in the case of the higher strength rock type, the use of a proportion of the excavated rock for backfilling (which would meet crushed rock backfilling requirements) would negate the need to import crushed rock for backfilling, which could otherwise affect aggregates supply elsewhere. The potential also exists for the beneficial use of the surplus excavated rock to be removed off-site (such as use for aggregates).

The potential effect of a GDF for the Derived Inventory Upper Inventory on sites of geological importance and mineral resources or reserves could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility footprint. The footprint of the underground facility for the higher strength rock type is assumed to be at least 4.3km² for the Derived Inventory Reference Case excluding Pu/U and 9.8km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). The magnitude of effect of the construction works would be potentially high given the area and volume of rock affected and the duration of the effect. However, the significance would depend on the quality and type of excavated rock, its availability and its usage.

Excavations into the higher strength rock could affect the stress distribution in the rock and potentially result in a fall of ground. These activities could also create new rock fractures (or increase the existing fracture network) which in turn could reduce the mechanical strength of the rock, increase its hydraulic permeability and/or create locally new flow pathways for water. The latter has the potential to adversely affect the rock chemistry locally (i.e. weathering).

However, although there would be the potential for effects, it is not anticipated that excavation activities would have any significant adverse effects on the physical or chemical stability of the surrounding geology or the background level of seismicity as a stable geological environment is essential for a GDF and the site would have been chosen on this basis. Ground movement can be controlled by the application of geotechnical mapping and testing to ensure that appropriate rock support is provided. The use of concrete hydrostatic lining, a nominal concrete lining and/or rock bolting would prevent structural instability. Phasing construction, keeping the vaults open for relatively short periods of time, and the backfilling of the vaults and disposal tunnels (refer to the operational phase assessment), would also provide long-term support. In addition, hydrostatic pressure resistant lining would also be used where necessary to prevent groundwater ingress (refer to Sustainability Theme 5A).

Assumptions and uncertainties: It is assumed that the site would be greenfield with no previous history of contamination. Subsequently, it is unlikely that construction would result in the mobilisation of contaminants through the soil profile. The scale of surface development is assumed to be the same for the different waste inventories.

It is assumed that the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore there would probably not be any difference in effects on soils associated with surface construction activities between the different waste inventories.

Proposed Mitigation/Enhancements:

Any geological features of value (e.g. SSSIs or RIGS) should be avoided where possible.

Good practice guidance in the protection of soil materials should be followed: Guidance on Good Practice for the Reclamation of Mineral Workings to Agriculture (Department of the Environment, 1996) and Good Practice for Handling Soils (Ministry of Agriculture, Fisheries and Food, 2000).

The site should be carefully stripped of topsoils prior to construction works commencing to avoid damage. All soils should be handled in suitable conditions (e.g. dry weather) and the most appropriate method of soil handling should be used. Soils should be stored in allocated heaps and protected from erosion, contamination or degradation. Different soil types should be stored separately and the length of time soils are stored should be minimised where possible. Soil excavation and mounds should avoid compaction where possible by making use of appropriate wide tracked vehicles and avoiding working on soil when it is wet. Appropriate drainage systems should be utilised on site to reduce soil erosion.



4. Geology and Soils

A. Higher Strength Rock (cont)

Opportunities for the beneficial re-use of excavated rock to be removed off-site should be explored. For example, excess excavated rock could be exported via railhead for use as aggregate/construction material. The transport implications of exporting excavated rock off-site would need to be considered carefully. Where possible, the disposal of excavated rock to landfill should be avoided. The available options should be subject to environmental assessment.

Site soils may be used to cover proposed surface bunds around site. The mounds should be shaped to shed rainwater. A suitable grass seed mix could be used to provide a vegetation cover and reduce the risk of soil erosion from surface run-off.

Summary of information requirements: Site-specific information is required to determine the potential for land contamination and to establish the likelihood of any effects on soils, designated geological sites and mineral resources or reserves. It is anticipated that the regional surveys, subsequent site-specific surveys and the periodic mapping/inspection undertaken during each construction cycle would provide the necessary information to determine the effects and subsequent mitigation required.

B. Lower Strength Sedimentary Rock

For the lower strength sedimentary rock type, the potential effects that could occur and the potential mitigation/enhancements relating to soils and the physical and chemical stability of the host rock are considered to be the same as those identified for higher strength rock (refer to 4A. Higher Strength Rock). However, the scale of any effects associated with excavated rock could differ when compared to the higher strength rock type.

In the case of the lower strength sedimentary rock the construction of a GDF would require approximately 4,820,000m³ of rock to be excavated for the Derived Inventory Reference Case excluding Pu/U and 11,775,000m³ for the Derived Inventory Upper Inventory. In the case of lower strength sedimentary rock, it is proposed that approximately 3,589,000m³ of the excavated rock would be used to construct surface bunds around the site. The remainder of the excavated rock, estimated to be approximately 1,231,000m³ for the Derived Inventory Reference Case excluding Pu/U and 8,186,000m³ for the Derived Inventory Upper Inventory, would be taken off-site. None of the excavated rock would be used for backfilling, as the excavated rock would not be suitable for this.

The potential effect of the lower strength sedimentary rock type on sites of geological importance could be greater when compared to the other host rock types, due to the increased size of the underground facility footprint. It is assumed to be at least 7.8km² for the Derived Inventory Reference Case excluding Pu/U and 19.5km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). The construction of the underground facility within the lower strength sedimentary rock would probably not have a significant effect on minerals resources or reserves, due to its low commercial value.

C. Evaporite Rock

The potential effects that could occur and the potential mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 3A. Higher Strength Rock). However, the scale of any effects associated with excavated rock could differ when compared to the higher strength rock type.

In the case of the evaporite rock the construction of a GDF would require approximately 4,273,000m³ of evaporite rock to be excavated for the Derived Inventory Reference Case excluding Pu/U and 11,366,000m³ for the Derived Inventory Upper Inventory. None of the excavated rock would be stored in bunds within the surface site area for the evaporite rock type, as the excavated rock would not be suitable for this. However, a proportion of the excavated rock would be retained on site within a dedicated storage area and used as backfill material (estimated to be around 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory for the backfilling of the HLW/SF disposal tunnels, shafts and common services area). The remainder, estimated to be approximately 3,100,879m³ for the Derived Inventory Reference Case excluding Pu/U and 8,549,879m³ for the Derived Inventory Upper Inventory, would be taken off-site.

Evaporite rock can be of commercial value: halite in particular is used widely in the UK as rock salt for winter de-icing of roads, and for chlorine production, food seasoning and medicinal purposes. Anhydrite is used in cement manufacture (i.e. Portland cement), as a source of sulphur and as mineral filler in plastics, paints and paper. There is therefore the potential for the beneficial use of the remainder of the excavated rock to be removed off-site.



4. Geology and Soils

C. Evaporite Rock (cont)

The potential effect of the evaporite rock type on sites of geological importance and minerals resources/reserves could be greater when compared to the higher strength rock type, due to its larger underground facility footprint, which is assumed to be at least 6.5km² for the Derived Inventory Reference Case excluding Pu/U and 18.4km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). Therefore a greater area could be affected.

Although the surface site area is assumed to be 1.1km², given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types, there is the possibility that surface disturbance could be less for the evaporite rock type, reducing potential effects on soils. However, as the excavated evaporite rock would not be suitable for surface bunding, any surface screening bunds required within the site would need to be created using spoil and imported material as required.

Headline Issues

	<ul style="list-style-type: none"> - Loss of soil and rock in the footprint of surface facilities/infrastructure (buildings, hardstanding and access roads) and in the footprint of the excavation works. <p>There would probably not be any significant difference in potential effects on soils associated with surface construction activities between the different waste inventories and host rock types, as the surface site area is assumed to be the same (approximately 1.1km², assuming that the surface site area for the evaporite rock type includes surface screening bunds).</p> <ul style="list-style-type: none"> - Notwithstanding this, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type, reducing potential effects on soils. However, as the excavated evaporite rock would not be suitable for surface bunding, any surface screening bunds required within the site would need to be created using spoil and imported material as required.
	<ul style="list-style-type: none"> - Generation of large volumes of surplus excavated rock requiring removal off-site (with the associated effects on transport, nuisance, waste and resources). - Potential for the excavation of large volumes of rock to affect sites of recognised importance for their geological value. - Potential for the construction of the underground facility within higher strength rock and evaporite rock to result in the sterilisation of a minerals resource, or minerals reserve where a site is covered by valid planning permissions for the extraction of minerals. <p>Taking account of scale, there is the potential for the lower strength sedimentary rock type to have a greater impact upon sites of geological importance when compared to the higher strength rock and evaporite rock types, as the underground facility footprint would be greater (7.8km² for the Derived Inventory Reference Case and 19.5km² of the Derived Inventory Upper Inventory) when compared to higher strength rock (4.3km² and 9.8km² respectively) and evaporite rock (6.5km² and 18.4km² respectively).</p> <p>There would be the potential for the construction of a GDF within higher strength rock and evaporite rock to result in the loss or sterilisation of a mineral resource or a mineral reserve. The evaporite rock type could potentially have the greatest effect as the underground facility footprint would be greater when compared to higher strength rock. However, In the case of the higher and evaporite rock types, the use of some of the excavated rock for backfilling (the excavated rock retained on site is likely to meet crushed rock HLW/SF disposal tunnel, drift and/or shaft and commons service area backfilling requirements) would negate the need to import crushed rock for backfilling for these purposes, which could otherwise affect mineral resources supply elsewhere. The potential also exists for the beneficial use of surplus excavated rock to be removed off-site, particularly the evaporite rock halite, which is used widely in the UK as rock salt for winter de-icing of roads, for chlorine production, for food seasoning and for medicinal purposes. Although the underground facility for the lower strength sedimentary rock type would have the greatest footprint, this type would be unlikely to have a direct effect on mineral resources or mineral reserves, due to its low commercial value.</p>



4. Geology and Soils

Headline Issues (cont)

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Rock stability varies by rock type, with the structural stability and mechanical strength of higher strength rock generally would be greater than that of the other host rock types, with the evaporite rock being the weakest. The design and construction method can also influence structural stability. For example, the spacing between excavations can affect the stress regime in and around the excavated area and also influences the loading of the intervening strata. Similarly, rock stresses increase with depth such that the stability of underground excavations tends to reduce with increasing depth and increasing stress. However, there would probably not be a significant difference in potential physical stability effects between the different host rock types, as a stable geological environment is essential for a GDF and the facility would be designed and constructed to ensure that the likelihood of any instability is minimised.

5. Water

A. Higher Strength Rock

Assessment of Effects:

Water would be required throughout the construction phase for use in construction activities (e.g. for cement mixing, drilling fluid, cleaning machinery, dust suppression, pressure testing and cooling equipment). During construction water would also be required for potable purposes such as drinking water and canteen use, as well as toilet and washing facilities and laundering protective clothing. Potential sources of supply include the use of mains supply water or surface or groundwater abstraction. Depending on local water resource availability and demand at the site, there would be the potential for water use to affect the availability of water for other licensed water abstractors within the catchment, or for environmental flow targets to be adversely affected. The potential effects on water resources would be assessed in the determination of any new abstraction licenses by the Environment Agency (EA) or equivalent regulator.

Construction activities would generate several sources of water requiring discharge, including surface run-off, groundwater from dewatering, any effluent arising from water use on site and foul water. Discharge from the site could affect the water quality and/or rate of flows of receiving waters. Surface run-off could contain contaminants released through spillage of materials used during construction such as chemicals and fuels. Drilling activities may also introduce contaminants to groundwater sources (e.g. drilling fluid), and water used as drilling fluid is likely to have a high sediment load, which could affect water quality if discharged untreated. Drill and blasting could produce fracture zones in the rock which act as conduits for groundwater, and hence the possibility of groundwater contamination from these excavations during construction.

Permeability varies by rock type, with a greater potential for faults and fracturing within the higher strength rock. It is likely that the greatest potential for groundwater ingress within excavations would be during construction of the access routes to the underground facility. The removal of potentially significant quantities of groundwater (dewatering) could be required temporarily during the construction of the shafts and drift through near surface geological deposits. Where effects from groundwater ingress are likely, it is assumed that pre-treatment would be carried out (e.g. grouting or other groundwater control techniques), followed by hydrostatic pressure resistant lining where necessary to minimise ingress. Once construction reaches the host higher strength rock inflows would be reduced. The presence of the drift and access shafts, and grouting/lining that may take place around them would reduce the transmissive capacity of water bearing formations (aquifers) on a localised scale. In the long-term some small inflows would be anticipated, both into the shafts and drift, and the facility itself.

Water removed by dewatering would require disposal. Typically this would be to surface water or by injection back into an aquifer formation following treatment. Assuming water is discharged back to the aquifer following treatment there is unlikely to be any significant net loss to the groundwater system; the rate of any groundwater ingress to the excavated areas following excavation is likely to be low. If treated water is discharged to a surface watercourse this would affect groundwater resources, as well as significantly increasing surface water flows if on site storage and attenuation were not put in place.

It is assumed that the potential effect of a GDF for the Derived Inventory Upper Inventory on groundwater could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows and may result in greater levels of dewatering. The footprint of the underground facility for the higher strength rock type is assumed to be at least 4.3km² for the Derived Inventory Reference Case excluding Pu/U and 9.8km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area).



5. Water

A. Higher Strength Rock (cont)

Surface construction activities, particularly site clearance and levelling, the introduction of hardstanding, and the construction of surface bunds from the excavated rock may increase flood risk during the construction phase, due to changes to surface drainage patterns and the increase in impermeable surface areas, affecting run-off rates and flow pathways. For the higher strength rock type the surface site area is assumed to be approximately 1.1km², which would include surface facilities and infrastructure, and up to 3,589,000m³ of excavated rock stored in bunds.

Assumptions and uncertainties: It is assumed for the purposes of this assessment that the site would be greenfield. The scale of surface development is assumed to be the same for the different waste inventories. It is assumed that the host rock in which a GDF is to be constructed would be a minor or non aquifer. However this would need to be assessed when each particular site location is determined. The significance of the effect on flood risk would be dependent, in part, on whether the site is situated in a flood risk area, which at this stage is uncertain.

It is assumed that the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore there would probably not be any difference in effects on surface water quality and flood risk associated with surface construction activities between the different waste inventories.

Proposed Mitigation/Enhancements:

Where possible, surface facilities and infrastructure should be located to minimise any effect on hydrology as far as possible. Surface mapping undertaken as part of the regional surveying at the surface-based site investigations phase can inform the identification of areas that may be most at risk and allow a concentrated focus on prevention.

Potential sources of water resources for use during works should be identified at an early stage and abstraction from the source should result the lowest environmental effect possible.

Design for surface water drainage should incorporate sustainable techniques (SUDS) where possible which incorporate surface storage and attenuation, and infiltration to ground if near surface hydrogeology is suitable. Assuming the site is greenfield, run-off from rainfall should be limited to greenfield rates agreed with the EA or equivalent body prior to design. In line with the requirements of Planning Policy Statement (PPS) 25 and other equivalent policies, SUDS should be used to attenuate any increases in surface run-off rates.

A Flood Risk Assessment (FRA) should be carried out which assesses all potential sources of flood risk and identifies any mitigation measures necessary to ensure flood risk at the site or down catchment is not increased during construction (or subsequently). The FRA should include a surface drainage strategy, detailing how run-off from rainfall would be discharged from the site at rates no higher than those from the pre-existing site, and preferably at lower rates, up to the 50 year rainfall event, allowing for climate change. The FRA would need to meet the requirements of PPS 25: Development and Flood Risk (England), TAN 15 (Wales) or other equivalent policy.

Measures to reduce the risk of pollution incidents and accidental discharge and to control the rates of water discharged from the site should be outlined within an Environmental Management Plan. These should follow best practice pollution prevention guidelines produced by the EA or equivalent bodies. Measures include the use of impermeable membranes, bunded and tanked fuel storage, double lined settlement lagoons and interceptors. All discharges off-site would be agreed with the EA or equivalent body. Discharges to surface water or groundwater would require EA consent.

Settlement lagoons should be adequately protected through the use of double linings to prevent loss and appropriately sited to mitigate the risks of contaminating groundwater or surface water bodies in the case of flooding.

The handling of any hazardous materials or fluids must be carried out in accordance with relevant best practice guidance and make use of bunds and suitable storage tanks effectively providing sealed areas with adequate storage and collection facilities.

A Spillage Response Plan should be developed and implemented, which sets out systems to ensure that pollution effects are contained and minimised and that clean-up procedures and spill kits are in place to respond effectively once an incident is discovered. Training should be provided to all staff working on the site on the spill response procedures and periodic auditing of the procedures should take place. Sufficient spill kits should be provided and maintained and the contents should be subject to periodic checks.

Drilling specifications should ensure appropriate composition and design of both drilling fluid and use of casing to prevent entry of drilling fluids through excavated walls to groundwater. Regular monitoring of fluid flows and stored volumes should also form a component of the drilling specifications. Mud pits (settlement lagoons for the drilling fluids) should be adequately protected through the use of double linings to prevent loss and appropriately sited to mitigate the risks of contaminating groundwater or surface water bodies in case of flooding.



5. Water

A. Higher Strength Rock (cont)

The design for excavations should include grouting or lining of shafts and the drift tunnel as necessary to minimise ingress of water after construction. The timing and phasing of excavations should be planned to minimise the duration for which dewatering activities are required. Adequate treatment of dewatering water (settlement to reduce turbidity) should be carried out prior to disposal. Where possible this water should be re-injected into the main water bearing formation from which it was pumped, to minimise negative effects on water resources within this unit. A dewatering plan should be agreed with the EA or equivalent body prior to construction.

Implementation of water efficiency and re-use measures on site (demand management techniques, grey water recycling and rain water harvesting) should be implemented where appropriate, to minimise demand for water resources and consequential environmental effects.

Where wastewater is not to be discharged to sewer it should be treated on site to acceptable standards before being discharged to local watercourses. On site treatment would include reedbeds and other sustainable treatment processes where appropriate, thereby adding biodiversity value to the site.

Summary of information requirements: Site-specific information is required to determine the potential effects on water resources and flood risk, particularly groundwater. It is anticipated that the regional surveys, subsequent site-specific surveys and the periodic mapping/inspection undertaken during each construction cycle would provide the necessary information to determine the effects and subsequent mitigation required. Site-specific topographic and geological information would be essential to support rigorous design and specification of detailed mitigation measures. A FRA should be undertaken to determine potential flood risk and required mitigation (refer to the proposed mitigation). Regulatory discharge and abstraction permitting would be site-specific.

B. Lower Strength Sedimentary Rock

The potential effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 5A. Higher Strength Rock). However, the scale of any effects associated with excavated rock could differ when compared to the higher strength rock type.

Permeability varies by rock type, with minimal fracturing in the assumed lower strength sedimentary rock. Notwithstanding this, the footprint of the underground facility for the lower strength sedimentary rock type would be greater than that of the other host rock types. It is assumed to be at least 7.8km² for the Derived Inventory Reference Case excluding Pu/U and 19.5km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). The potential effect of a GDF for the lower strength sedimentary rock type on groundwater could therefore be greater than that of the other host rock types due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows and may result in greater levels of dewatering.

In addition to the potential effects identified for the higher strength rock, there is the potential that low strength sedimentary rocks may contain sufficient sulphide to cause acid generating reactions on exposure to air and water, giving rise to the potential for contamination of surface watercourses with low pH waters. This potential effect could be mitigated by limiting exposure to air and water by establishing surface bunds quickly and in dry conditions, and by the rapid covering of excavated rock with spoil. Depending on the acid-generating potential, the excavated rock may also need to be sat on impermeable bases and run-off managed to reduce the potential for leachate. Further information is required to determine the potential for effects and subsequent mitigation required.

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 5A. Higher Strength Rock). However, the scale of any effects associated with excavated rock could differ when compared to the higher strength rock type.

Similar to the higher strength rock type, the surface site area for the evaporite rock type is assumed to be approximately 1.1km². However, in the case of the evaporite rock type, this would include a dedicated storage area for excavated rock (approximately 1,172,121m³ and 2,816,121m³ for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively) and surface screening bunds. Given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types (approximately 3,589,000m³ in bunds on the site for the higher and lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type, which could reduce any potential surface water quality and flood risk effects.



5. Water

C. Evaporite Rock (cont)

Depending on the evaporite host rock type, any excavated host rock stored on the surface could present a potential pollution risk. The evaporite rock type halite is highly soluble in fresh water, and therefore if excavated halite rock were to come in contact with water the potential would exist for the contamination of surface watercourses with high chloride waters. This could be mitigated for by storage under cover. The evaporite rock anhydrite, however, is less soluble, and therefore the pollution risk would be less than that of halite.

Permeability varies by rock type; within evaporite rock migration pathways are virtually absent. However, the footprint of the underground facility for the evaporite rock type would be greater than that of the higher strength rock type. The underground facility footprint for the evaporite rock type is assumed to be at least 6.5km² for the Derived Inventory Reference Case excluding Pu/U and 18.4km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). The potential effect of a GDF for the evaporite rock type on groundwater could therefore be greater than that of the higher strength rock type due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows and may result in greater levels of dewatering.

Headline Issues

- Increase in water use throughout the construction phase, which has the potential to affect water availability for other licensed abstractors, or for environmental flow targets to be adversely affected.
- Potential for surface construction activities to increase flood risk due to changes in surface drainage patterns and the increase in impermeable surface areas.
- Potential for construction activities to affect water quality and/or rate of flows of receiving waters.

For all three host rock types, there would probably not be any significant difference in potential run-off and flood risk effects between the different waste inventories, as the surface site area is assumed to be the same. Notwithstanding this, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type, which could reduce any potential surface run-off and flood risk effects.

For all host rock types it is assumed that the potential effect of the Derived Inventory Upper Inventory on groundwater could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows and may result in greater levels of dewatering.

There would be the potential for the different host rock types to affect the scale of any effects on water resources and flood risk. In the case of lower strength sedimentary rock and evaporite rock (depending upon its type), due to the nature of these host rock types, there would be the potential for excavated rock stored within the surface site area to negatively affect water quality. Lower strength sedimentary rock may contain sufficient sulphide to cause acid generating reactions on exposure to air and water, giving rise to the potential for contamination of surface watercourses. Similarly, the evaporite rock type halite is highly soluble in fresh water and therefore if excavated halite rock were to come in contact with water the potential would exist for the contamination of surface water courses with high chloride waters. The evaporite rock anhydrite, however, is less soluble, and therefore the pollution risk would be less than that of halite.

Permeability varies by rock type, with a greater potential for faults and fracturing within the higher strength rock. Lower strength sedimentary rock may have minimal fracturing, and within evaporite rock migration pathways are virtually absent. The greatest potential for groundwater ingress within excavations is during construction of the access routes through the near surface geological deposits, which are assumed to be similar for all three host rock types. Notwithstanding this, the lower strength sedimentary rock type could potentially have the greatest effect on groundwater flows as the underground facility footprint (7.8km² and 19.5km² for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory) would be greater when compared to the higher strength rock type (4.3km² and 9.8km²) and evaporite rock type (6.5km² and 18.4km²).



6. Biodiversity, Flora and Fauna

A. Higher Strength Rock

Assessment of Effects:

There would be the potential for construction activities on the surface to affect biodiversity associated with the site and its surrounds. The key effects associated with construction activities can be generally categorised as habitat loss due to development, habitat change, disturbance of fauna, alteration of hydrological regimes and the deposition of pollutants on to surrounding areas (mostly associated with increased volumes of traffic). The potential receptors that may be affected, depending on the specific site location include statutory designated sites (e.g. Special Area of Conservation (SAC), Special Protection Areas (SPA) and SSSI), non statutory designated sites (e.g. Sites of Nature Conservation Interest/Importance (SNCI) or County Wildlife Sites) and other protected and notable habitats and species.

The greatest potential effect during construction would be any loss of habitat and disturbance/displacement of wildlife from the site area and its surrounds. Loss of habitat could be both direct (e.g. loss to hard engineering) and indirect (e.g. changes in character due to alterations in drainage patterns and deposition of pollutants) and could result in fragmentation of surrounding habitats. For the higher strength rock type the surface site area is assumed to be approximately 1.1km², which would include surface facilities and infrastructure, and up to 3,589,000m³ of excavated rock stored in bunds.

Disturbance/displacement of fauna is likely to be caused by a range of factors such as noise (particularly intermittent blasting), human presence and light pollution; the effect of disturbance has the potential to reduce the rates of breeding success and survival resulting in detectable falls in the size of local populations of fauna. The potential for substances associated with the construction process (e.g. diesel, drilling fluid) and silt laden run-off to escape in to the surrounding environment also has the potential to affect notable flora and fauna, as does the increased deposition of pollutants associated with heavy traffic movements.

There would be the potential for the construction of new road and/or rail infrastructure to affect biodiversity (e.g. the works may result in the loss or fragmentation of habitat and displacement/disturbance of species). Similarly, any improvements to the local road network required to support construction traffic movements may result in the loss of habitat due to widening or structural upgrading; this is not anticipated to be significant, although there would be the potential for features such as species rich hedgerows and specimen trees to be affected.

Depending on its end use, there would also be the potential for the removal of surplus excavated rock off-site to affect biodiversity. For example, direct loss or fragmentation of habitat at the point of loading and unloading for disposal or reuse, or indirect effects due to alterations in drainage patterns or the deposition of pollutants.

Assumptions and uncertainties: It is assumed for the purposes of this assessment that the site would be greenfield. The surface site area and the scale of surface development is assumed to be the same for the different waste inventories. It is assumed that construction material and construction wastes (with the exception of excavated rock) would be transported to and from the site via road. It is assumed that all of the excavated rock to be removed off-site from the construction of the underground facilities would be transported off-site via rail.

At this stage no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the biodiversity value of the site and its surrounds, the sensitivity of any habitats/species present, and the level of habitat disturbance or loss. It is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore there would probably not be any difference in potential effects between the different waste inventories.

Proposed Mitigation/Enhancements:

As potential site locations are identified a Habitats Regulations Assessment (HRA) may be required to identify the potential effects on European protected habitats and species and propose specific mitigation measures to minimise any detrimental effects identified.

At an early stage following site selection and prior to any works on site, a desk-based assessment followed by surveys (site walkover surveys followed by detailed species specific surveys in areas likely to be subject to direct disturbance) as appropriate should be undertaken to determine the biodiversity value of the site (it is expected that a desk study and survey(s) would have been undertaken as part of the surface-based site investigation works, which could be revised and updated as necessary for the construction phase).

The design and layout of a GDF should seek to retain or minimise loss of any valuable biodiversity habitat or features, whilst retaining linkages (i.e. wildlife corridors) between areas that have the potential to be isolated by development. Careful consideration should be given to the routing of access roads and rail infrastructure to prevent or minimise habitat fragmentation. Where an effect cannot be adequately mitigated then appropriate compensation measures would need to be developed.



6. Biodiversity, Flora and Fauna

A. Higher Strength Rock (cont)

Any opportunities for habitat creation or enhancement should be pursued (e.g. the use of visual screens, spoil heaps and sustainable drainage systems to create wildlife habitat) within the initial design process to ensure the most favourable and practical solutions are achieved. Any opportunities to contribute towards or meet Local Biodiversity Action Plan targets should be pursued.

The containment of spillages and run-off and control of ground water pollution (e.g. through drilling) should be managed appropriately following standard pollution prevention guidance incorporating measures (refer to Sustainability Theme 5A).

Summary of information requirements: Site-specific information is required to establish the likelihood of any effects on biodiversity (refer to the proposed desk-based assessment and survey mitigation). Future assessments should take account of the type, features and conservation characteristics of habitats in the area, especially any designated areas (e.g. SSSI, SAC, Ramsar etc). Species diversity and their conservation designation should be considered to accurately gauge the likely significance of the effects.

B. Lower Strength Sedimentary Rock

The potential effects of the lower strength sedimentary rock type on biodiversity that could occur and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 6A. Higher Strength Rock).

No effects in addition to those identified for higher strength rock have been identified.

Similar to the higher strength rock type, the surface site area for the lower strength sedimentary rock type is assumed to be approximately 1.1km², which would include surface facilities and infrastructure, and up to 3,589,000m³ of excavated rock stored in bunds.

C. Evaporite Rock

The potential effects of the evaporite type on biodiversity that could occur and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 6A. Higher Strength Rock).

Similar to the higher strength rock type, the surface site area for the evaporite rock type is assumed to be approximately 1.1km². However, in the case of the evaporite rock type, the surface site area would include surface facilities and infrastructure, a dedicated storage area for excavated rock (approximately 1,172,121m³ and 2,816,121m³ for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively) and surface screening bunds. Given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types (approximately 3,589,000m³ in bunds on the site for the higher and lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type, which could reduce any potential effects on biodiversity.

Headline Issues

- Potential loss or fragmentation of habitat within the site area as a result of surface construction activities.
- Potential for the disturbance/displacement of conservation notable species from the site and its surrounds as a result of construction activities (e.g. such as noise, human presence and light pollution).

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There would probably not be any significant difference in potential effects on biodiversity between the different waste inventories and different host rock types, as the surface site area is assumed to be the same (approximately 1.1km², assuming that the surface site area for the evaporite rock type includes surface screening bunds). Notwithstanding this, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type, which could reduce any potential biodiversity effects.

At this stage no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the biodiversity value of the site and its surrounds, the sensitivity of habitats/species present, and the level of habitat disturbance or loss.



7. Traffic and Transport

A. Higher Strength Rock

Assessment of Effects:

The construction of a GDF would result in a significant increase in transport movements on the local road network associated with construction staff, HGVs, a range of heavy plant construction vehicles, concrete tankers and deliveries throughout the construction phase.

It is estimated that the volume of higher strength rock excavated during construction of the underground facilities would be approximately 5,225,000m³ for the Derived Inventory Reference Case excluding Pu/U and 13,800,000m³ for the Derived Inventory Upper Inventory. For the higher strength rock type, it is proposed that a proportion of the excavated rock (approximately 3,589,000m³) would be stored in bunds within the site, and a proportion of the excavated rock would be used as crushed rock backfill material (for backfilling the HLW/SF disposal tunnels, the drift and shafts, and the common services area). This would reduce the amount of excavated rock to be removed off-site, and would negate the need to import any crushed rock for backfilling of these areas once backfilling commences (refer to the operational and closure & post-closure phase assessments), which would otherwise generate a significant number of transport movements.

In the case of the Derived Inventory Reference Case excluding Pu/U, all of the higher strength rock excavated during the construction of the underground facilities would be utilised on site (taking account of the volumes of excavated rock to be stored in surface bunds and used for backfilling of the HLW/SF disposal tunnels, the drift and shafts, and the common services area). No excavated rock would therefore need to be transported off-site. For the Derived Inventory Upper Inventory, not all of the excavated rock would be utilised on site. The surplus excavated rock, estimated to be approximately 6,640,921m³, would be taken off-site. However, it is assumed that all of the excavated rock would be transported off-site by rail, which would otherwise generate a significant number of transport movements by road, and therefore no significant effects on the road network from the transport of excavated rock are anticipated.

During the construction phase, the delivery of construction materials to the site would generate a significant number of transport movements.

The transport of materials for the construction of the surface-based facilities, drift and shafts and common services area could require approximately 12,100 HGVs for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory (as the scale of the surface facilities are expected to be the same).

The transport of construction materials for the higher strength rock ILW/LLW vaults and HLW/SF disposal tunnels could require an estimated 50,200 HGVs for the Derived Inventory Reference Case excluding Pu/U and an estimated 127,000 HGVs for the Derived Inventory Upper Inventory in total respectively.

Environmental effects that could be considered as potentially significant on the road network include severance to pedestrians/cyclists induced by the flow of vehicles along a road, driver delay, loss of pedestrian/cyclist amenity, and accidents and safety as a result of an increase in traffic on the highway network.

Depending on whether new road or rail infrastructure is constructed to serve a GDF, or whether existing road or rail infrastructure is utilised, it is unknown whether there would be any effects from additional transport infrastructure or on the national transport network.

It is assumed that the potential effects of the Derived Inventory Upper Inventory would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in the volume of construction materials required and construction waste generated, and the requirement to transport excavated rock off-site, resulting in a greater number of transport movements. No transport of excavated rock off-site would be required for the Derived Inventory Reference Case excluding Pu/U, as all excavated rock could be utilised on site.

Assumptions and uncertainties: It is assumed that all construction materials, machinery and any construction waste (with the exception of excavated rock) would be transported to and from the sites via road. It is also assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the site and may pass close to sensitive receptors such as residential areas. The assumptions made for the transport of construction materials by road are as follows: 10% of construction materials would be transported using a >3.5-7.5t HGV; 50% using a >7.5-17t HGV; and 40% using a >17t HGV. It is assumed that all of the excavated rock to be removed off-site from the construction of the underground facilities would be transported off-site via rail.

The significance of the traffic and transport effects of the construction phase would be dependant on the location of the site, the extent of use of rail facilities, the sensitivity of the local road network, the location of construction materials and the disposal point/end use of excavated rock removed off-site. This may affect the range of measures implemented to mitigate transport related effects. It should be noted that any effects on the road network would be significantly reduced where rail or sea is used as the sole or primary means of transport.



7. Traffic and Transport

A. Higher Strength Rock (cont)

Proposed Mitigation/Enhancements:

The Generic Disposal Facility Designs Report^[8] proposes the receipt of radioactive waste to the site via rail and/or road once the facility is in operation. Where practicable provision should be made for the transport of any plant, construction materials and construction wastes to and from the site via rail or sea. Other alternatives to road transport could be the use of conveyors (such as those used in quarrying and mining) as a means of transport to rail or port facilities. Consideration should be given to the potential longer term use of any new infrastructure provided: whether a dedicated transport link for a GDF is provided or whether there are opportunities for wider industrial/commercial use of any new transport infrastructure.

To minimise the movement of construction materials, locally sourced construction materials should be used where practicable and, where possible, any construction waste should be retained and used on site.

To reduce traffic effects during the construction phase of the development, the following mitigation should be implemented:

Tender specifications should provide information on traffic management requirements and request information from contractors on how measures would be implemented to mitigate traffic and transport effects.

A road safety audit of the site access design should be undertaken prior to construction to ensure that the access is an appropriate design, capable of accommodating construction and operational traffic, and would not compromise safety on the public highway.

A Traffic Management Plan (TMP) should be prepared and adopted. The TMP is likely to include details on car parking, temporary road signage and construction traffic routing and timing. Similarly, a Green Travel Plan should be developed and implemented, outlining measures to reduce private vehicle use such as the promotion of car sharing, the provision of services for construction workers to the site (i.e. buses) and the provision of public transport passes where the site is accessible by public transport

Traffic movements (particularly HGVs) should be limited along certain routes or at certain times of the day to minimise the effects of congestion and nuisance or intrusion on any nearby residents.

Routing strategies should be implemented for construction material transport in order to avoid, as far as possible, sensitive receptors and congestion effects. Deliveries should be co-ordinated by a logistics manager to prevent queuing of vehicles. Arrivals of materials should also be scheduled to outside of peak hours to minimise any disruption to the existing highway network.

A regularly serviced modern lorry fleet should be used for the collection of waste, transportation of plant and equipment.

The immediate area external to the site, including the site entrances and adjacent road/footpath, should be subject to regular sweeping and washing using a combination of manual and mechanical means. Lorries should pass through wheel washing installations prior to departure in order to minimise dirt on the roads.

Contributions could be made towards improving the road network and public rights of way where appropriate.

Summary of information requirements: All available transport options should be subject to environmental assessment to determine their effect and to inform the choice of transport options and necessary infrastructure. Site-specific information is required to establish the likelihood of any effects on traffic, such as the proposed transport method and site access, the capacity and sensitivity of the existing road network, and traffic routing. A Traffic Assessment should be undertaken following site selection and scheme design to determine the potential effects and required mitigation. A road safety audit of the site access design prior to construction would determine whether site access is capable of accommodating traffic and would not compromise safety on the public highway.

B. Lower Strength Sedimentary Rock

The potential traffic and transport effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 7A. Higher Strength Rock).

However, the scale of the effects could differ when compared to the higher strength rock type. For the lower strength sedimentary rock type it is estimated that the volume of rock excavated during construction of a GDF would be approximately 4,820,000m³ for the Derived Inventory Reference Case excluding Pu/U and 11,775,000m³ for the Derived Inventory Upper Inventory. In the case of lower strength sedimentary rock, it is proposed that a proportion of the excavated rock (approximately 3,589,000m³) would be stored in bunds within the site.



7. Traffic and Transport

B. Lower Strength Sedimentary Rock (cont)

The remainder of the excavated rock, estimated to be approximately 1,231,000m³ for the Derived Inventory Reference Case excluding Pu/U and 8,186,000m³ for the Derived Inventory Upper Inventory, would be taken off-site. It is assumed that all of the excavated rock would be transported off-site by rail, which would otherwise generate a significant number of transport movements by road, and therefore no significant effects on the road network from the transport of excavated rock are anticipated.

However, in the case of the lower strength sedimentary rock type none of the excavated rock would be retained on site for backfilling as it would not be suitable for this purpose. All backfill material would therefore need to be imported to the site once the facility is in operation, which would generate a significant number of transport movements once backfilling commences (refer to the operational and closure & post-closure phases assessment).

The transport of materials for the construction of the surface-based facilities, drift and shafts and common services area could require approximately 12,100 HGVs for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory (as the scale of the surface facilities are expected to be the same) as per the higher strength rock type.

However, the transport of construction materials for the lower strength sedimentary rock ILW/LLW vaults and HLW/SF disposal tunnels could require an estimated 32,200 HGVs for the Derived Inventory Reference Case excluding Pu/U and an estimated 77,400 HGVs for the Derived Inventory Upper Inventory in total respectively. Fewer transport movements when compared to the higher strength rock type,

C. Evaporite Rock

The potential traffic and transport effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 7A. Higher Strength Rock).

However, the scale of the effects could differ when compared to the higher strength rock type. For the evaporite rock type it is estimated that the volume of rock excavated during construction of a GDF would be approximately 4,273,000m³ for the Derived Inventory Reference Case excluding Pu/U and 11,366,000m³ for the Derived Inventory Upper Inventory.

In the case of the evaporite rock type, a proportion of the excavated rock would be retained on site in dedicated storage and used as backfill material for backfilling of the HLW/SF disposal tunnels, drift and shafts, and common services area (estimated to be around 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory). This would reduce the amount of excavated rock to be removed off-site, and would negate the need to import any crushed rock for backfilling of these areas once backfilling commences (refer to the operational and closure & post-closure phase assessments), which would otherwise generate a significant number of transport movements.

The remainder of the excavated rock, estimated to be approximately 3,100,879m³ for the Derived Inventory Reference Case excluding Pu/U and 8,549,879m³ for the Derived Inventory Upper Inventory, would be taken off-site. It is assumed that all of the excavated rock would be transported off-site by rail, which would otherwise generate a significant number of transport movements by road, and therefore no significant effects on the road network from the transport of excavated rock are anticipated.

However, as none of the excavated rock would be stored on site in bunds due to it not being suitable for this purpose, spoil may need to be transported to the site to construct surface bunds around the site, generating traffic movements. Although it is assumed that surface bunds would only be of a sufficient scale to adequately screen the site.

The transport of materials for the construction of the surface-based facilities, drift and shafts and common services area could require approximately 12,100 HGVs for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory (as the scale of the surface facilities are expected to be the same) as per the higher strength rock type.

However, the transport of construction materials for the evaporite rock ILW/LLW vaults and HLW/SF disposal tunnels could require an estimated 25,200 HGVs for the Derived Inventory Reference Case excluding Pu/U and an estimated 65,700 HGVs for the Derived Inventory Upper Inventory in total respectively. Fewer transport movements than the other host rock types.



7. Traffic and Transport

Headline Issues

- Increase in traffic movements on the local road network throughout the construction phase (i.e. HGVs, a range of heavy plant construction vehicles, concrete tankers, construction staff and deliveries), with potential severance, driver delay, pedestrian/cyclist amenity and safety implications.

For all host rock types, the potential effect of the Derived Inventory Upper Inventory in relation to traffic and transport would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in the volume of construction materials required and construction waste generated, and the increase in the volume of excavated rock to be removed off-site, resulting in a greater number of transport movements.

For all host rock types, the greatest numbers of transport movements associated with construction are estimated to arise from the import of construction materials to the site and the removal of surplus excavated rock off-site. There is anticipated to be a greater number of transport movements associated with the removal of excavated rock and the import of construction materials for the ILW/LLW vaults and HLW/SF disposal tunnels for the differing rock types depending on the type considered. For both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory, the evaporite rock type is estimated to generate the largest volume of excavated rock requiring removal off-site when compared to the other host rock types. However, in the case of all of the host rock types, it is proposed that surplus excavated rock would be transported off-site via rail and therefore no significant effects on the road network from the transport of excavated rock are anticipated. For the higher strength rock Derived Inventory Reference Case excluding Pu/U, as all of the excavated rock would be retained on site, no transport of excavated rock from the construction of the underground facilities would be required.

For both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory it is estimated that the higher strength rock type could require the greatest number of HGVs when compared to the lower strength sedimentary rock and evaporite rock types (taking account of the estimated number of HGVs required for the import of construction materials for the construction of the surface-based facilities, drift and shafts, ILW/LLW vaults and HLW/SF disposal tunnels and the common services area). The evaporite rock type is estimated to require the least number of HGVs for the import of construction materials when compared to the other host rock types.

An estimated 62,300 HGVs could be required to import construction materials for the surface-based facilities, drift and shafts, ILW/LLW vaults and HLW/SF disposal tunnels and the common services area for the higher strength rock Derived Inventory Reference Case excluding Pu/U, compared to 44,300 HGVs for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U, and 37,300 HGVs for the evaporite rock Derived Inventory Reference Case excluding Pu/U.

For the Derived Inventory Upper Inventory, an estimated 139,100 HGVs could be required to import construction materials for the construction of the surface-based facilities, drift and shafts, ILW/LLW vaults and HLW/SF disposal tunnels and the common services area for the higher strength rock, compared to 89,500 HGVs for the lower strength sedimentary rock type Derived Inventory Upper Inventory, and 77,800 HGVs for the evaporite rock type Derived Inventory Upper Inventory.

8. Air Quality

A. Higher Strength Rock

Assessment of Effects:

As noted in Sustainability Theme 7A, construction of a GDF would result in a significant increase in traffic movements on the local road network. Exhaust emissions from construction traffic (e.g. from HGVs, concrete tankers, personnel vehicles and deliveries) could lead to a decrease in local air quality, particularly as a result of increased levels of nitrogen oxides, nitrogen dioxide (NO₂) and particulates.

The greatest potential effect on air quality during construction could be associated with the import of construction materials to the site (refer to Sustainability Theme 7A). Exhaust emissions from construction plant and diesel engine emissions from diesel generators used to supply non mains power may also contribute to increases in particulate matter and gaseous pollutants (particularly NO₂ and carbon dioxide (CO₂)).

Dust generated from construction activities, particularly earthworks, soil stripping, storage and use of materials on site, and drilling and blasting could have an effect on local air quality if unmanaged.



8. Air Quality

A. Higher Strength Rock (cont)

The construction of a GDF within higher strength rock could result in more drilling and blasting which could spread dust emissions over a wider area than conventional earthworks. In addition, fumes from blasting such as carbon monoxide and nitrous oxide, could negatively affect local air quality.

The potential effect of the Derived Inventory Upper Inventory in relation to transport related air quality effects could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of GDF, with an associated increase in the volume of construction materials required and construction waste generated, resulting in a greater number of transport movements. No transport of excavated rock off-site would be required for the Derived Inventory Reference Case excluding Pu/U, as all excavated rock could be utilised on site.

Assumptions and uncertainties: Refer to Sustainability Theme 7A for the transport assumptions made.

As a site has not been selected at this stage, the extent of any air quality effects associated with the construction of a GDF is uncertain. The magnitude and significance of effects of emissions to air would depend on the location of the site and the sensitivity of the local environment, the extent of use of rail facilities, the proposed traffic routing and journeys, the location of construction materials and the end use of excavated rock removed off-site, which at this stage cannot be fully addressed. Notwithstanding this, all equipment would comply with UK Government emissions regulations and would be sited to minimise effects on nearby sensitive receptors.

Proposed Mitigation/Enhancements:

As noted in Sustainability Theme 7A, where practicable, provision should be made for the transport of construction materials and construction wastes via rail or sea. Other alternatives to road transport could be the use of conveyors (such as those used in quarrying and mining) as a means of transport to rail or port facilities. All available transport options should be subject to environmental assessment to determine their effect. Measures to reduce private vehicle use and transport distances should also be implemented (refer to Sustainability Theme 7A).

Measures to reduce the effects of increases in vehicular pollutant emissions and particulate matter should be implemented where possible. This could include: eco-driver training; ensuring all vehicle engines and plant on site are not left running; using low emission vehicles and plant fitted with catalysts, diesel particulate filters or similar devices; keeping plant well maintained and routinely serviced; requiring that all construction vehicles comply with exhaust emission regulations for their class; siting haul routes, and operating plant away from sensitive receptors (e.g. houses, schools and hospitals); and maximising energy efficiency.

Where possible, the use of mains electricity to power equipment and plant would be preferential to diesel or petrol powered generators. The potential for renewable energy generation (e.g. solar panels, dedicated wind turbines, ground source heat pumps or biomass boilers) to meet energy needs on site should be considered.

Any risk of causing nuisance dust arising from construction activities should be reduced by making use of Best Available Technology and selecting suitable energy efficient, low emission equipment. This may include the following measures to suppress dust: the use of wet sweeping and cleaning methods; use of vehicle wheel wash facilities; the enforcement of low speed limits along temporary roads; paving of haul routes on site even if temporary to prevent re-suspension of dust emissions; sheeting vehicles transporting loose or potentially dusty material; delivering fine powder materials in enclosed tankers/silos; storage of dusty materials away from site boundaries; minimising the amount of excavated material held on site; sealing or re-vegetating completed earthworks as soon as reasonably practicable; and the use of design/pre-fabrication to reduce the need for grinding, sawing and cutting. Mixing of cement, bentonite, grout and other similar materials should take place in enclosed areas remote from site boundaries and potential sensitive receptors.

The use of dense vegetation, screens and barriers to help reduce the effects of particulate matter should be considered, as should the orientation with respect to locally prevailing winds.

Ventilation systems should be appropriately designed in accordance with best practice, to minimise emissions of pollutants. Discharge stacks should be located more than 100m from any underground ventilation intake. Back-up systems and procedures should be in place to ensure that air quality is maintained in case of failure of the primary system or filtering.

Summary of information requirements: Site-specific information is required to establish the likelihood of any effects on local air quality and mitigation required. Following site selection, the existing local air quality needs to be established and any sensitive receptors identified (e.g. such as schools, homes and healthcare facilities). Further information on the levels of specific pollutants emitted from construction activities and the effect that these may have on baseline air quality (e.g. Air Quality Management Areas) is required.



8. Air Quality

B. Lower Strength Sedimentary Rock

The potential air quality effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 8A. Higher Strength Rock). No effects in addition to those identified for the higher strength rock type are anticipated.

However, the scale of any effects could differ when compared to the higher strength rock type. Similar to higher strength rock, for the lower strength sedimentary rock type the greatest potential effect on air quality during construction could be associated with the transport of construction materials to the site. Although in the case of the lower strength sedimentary rock, fewer HGVs could be required for this purpose when compared to the higher strength rock (refer to Sustainability Theme 7B).

C. Evaporite Rock

The potential air quality effects that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 8A. Higher Strength Rock). No effects in addition to those identified for the higher strength rock type are anticipated.

However, the scale of any effects could differ when compared to the higher strength rock type. Similar to higher strength rock, for the evaporite rock type the greatest potential effect on air quality during construction could be associated with the transport of construction materials to the site. Although in the case of the evaporite rock type, fewer HGVs could be required for this purpose when compared to the other host rock types (refer to Sustainability Theme 7C).

Headline Issues

- Potential for exhaust emissions from construction traffic to negatively affect local air quality, particularly transport associated with the import of construction materials, which is likely to generate the greatest number of road transport movements.
- Potential for dust generated during construction activities to negatively affect local air quality if unmanaged.
- Potential for exhaust emissions from plant and diesel engine emissions from diesel generators to result in an increase in particulate matter and gaseous pollutants (particularly CO₂ and NO₂).

For all host rock types, the potential effect of the Derived Inventory Upper Inventory in relation to transport related air quality effects could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in the volume of construction materials required and construction waste generated, and an increase in the volume of surplus excavated rock to be removed off-site, resulting in a greater number of transport movements.

As noted in Sustainability Theme 7, a greater number of HGVs could be required for the import of construction materials for the higher strength rock type (both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory) when compared to the other host rock types (taking account of the estimated transport movements for the import of materials for the construction of the surface-based facilities, access tunnels (drift and/or shafts) and common services area, and for the ILW/LLW vaults and HLW/SF disposal tunnels). Therefore the transport related air quality effect of the higher strength rock type associated with the import of construction materials could be greater.

9. Climate Change

A. Higher Strength Rock

Assessment of Effects:

The emission of CO₂ (due to the direct or indirect combustion of fossil fuel) from construction traffic and plant, any use of diesel generators, and the embodied energy within construction materials used would contribute to climate change. When considering the source of the construction material used, the distance and method of transportation would have a direct effect on overall carbon emissions (for example the different emissions associated with transport by road, rail or ship).



9. Climate Change

A. Higher Strength Rock (cont)

As noted in Sustainability Theme 7A, all excavated rock from the construction of the underground facilities would be transported off-site by rail. In the case of the Derived Inventory Reference Case excluding Pu/U, all of the higher strength rock excavated during the construction of the underground facilities would be utilised on site (taking account of the volumes of excavated rock to be stored in surface bunds and used for backfilling of the HLW/SF disposal tunnels, the drift and shafts, and the common services area). No excavated rock would therefore need to be transported off-site. For the Derived Inventory Reference Case excluding Pu/U, the transport of surplus excavated rock off-site is estimated to generate in the region of 254,200 tonnes of CO₂ for the Derived Inventory Upper Inventory.

The transport of materials for the construction of the surface-based facilities is estimated to generate in the region of 4,000 tonnes of CO₂ for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory (as the scale of the surface facilities are expected to be the same).

Similarly, the transport of materials for the construction of the underground accesses (drift and shafts) and the common services area is estimated to generate in the region of 400 tonnes of CO₂ and 1,200 tonnes of CO₂ respectively for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory.

The transport of construction materials for the higher strength rock ILW/LLW vaults and HLW/SF disposal tunnels could generate in the region of 22,200 tonnes of CO₂ for the Derived Inventory Reference Case excluding Pu/U and 56,100 tonnes of CO₂ for the Derived Inventory Upper Inventory respectively.

With respect to embodied carbon, for the construction phase the total embodied CO₂ is estimated to be in the region of 432,500 tonnes for the Derived Inventory Reference Case excluding Pu/U and 1,097,500 tonnes for the Derived Inventory Upper Inventory (taking account of the embodied carbon in the surface facilities, underground accesses (drift and shafts), common services area and ILW/LLW vaults and HLW/SF disposal tunnels).

The embodied CO₂ in the surface-based facilities, underground accesses (drift and shafts) and common services area is estimated to be 97,700 tonnes for both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory (as the scale of the surface facilities are expected to be the same).

The embodied CO₂ in the ILW/LLW vaults and HLW/SF disposal tunnels is estimated to be 334,800 tonnes for the Derived Inventory Reference Case excluding Pu/U and 999,800 tonnes for the Derived Inventory Upper Inventory respectively.

The construction support facilities or underground facility would not be particularly vulnerable to the effects of climate change other than potential flooding from increased frequency and magnitude of storms if the site was located within an area at risk of flooding or surface water run-off was not managed appropriately. Given that the majority of the construction activities would be underground, changes in weather patterns as climate changes (e.g. very cold winters and hotter drier summers) would be unlikely to significantly affect the construction programme for a GDF.

Should the site be located on the coast, coastal erosion, sea level rise and storm surges could potentially have a negative effect on surface facilities and infrastructure. However, it is assumed given the nature of a GDF that the site would be adequately protected and resilient to coastal change.

The potential effect of the Derived Inventory Upper Inventory in relation to transport related carbon emissions, and the carbon embodied in construction material, would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased GDF size, with an associated increase in the volume of construction materials required and construction waste generated, and increase in the volume of surplus excavated rock to be removed off-site. Any transport related carbon emissions would be significantly reduced where rail or sea is used as the sole or primary means of transport.

Assumptions and uncertainties: It is assumed that the surface site and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore there would probably not be a significant difference in potential climate change effects associated with surface construction between the different waste inventories.

At this stage no site has been selected and therefore the location of the site in relation to floodplains or flood sensitive areas is unknown.

Proposed Mitigation/Enhancements:

Development should not be considered within areas at risk of flooding from rivers or the sea unless the development can be protected to an appropriate degree. Drainage on site should be sufficient to manage surface water flows and minimise risk of site flooding during heavy rainfall.



9. Climate Change

A. Higher Strength Rock (cont)

All infrastructure key to the running of the facility, such as power supply and computer systems should be designed to be fully resilient to flooding such that in the event of any localised flooding, the facility can remain fully safe and secure.

As noted in Sustainability Theme 7A, and where practicable, provision should be made for the transport of construction materials and construction wastes via rail or sea. Other alternatives to road transport could be the use of conveyors (such as those used in quarrying and mining) as a means of transport to rail or port facilities. All available transport options should be subject to environmental assessment to determine their effect.

Measures to reduce private vehicle use and transport distances should also be implemented (refer to Sustainability Theme 7A).

Other alternatives to road transport could be transport via sea where a coastal location is proposed, and the use of conveyors as a means of transport to rail or port facilities. All available transport options should be subject to environmental assessment to determine their effect.

Where possible, construction materials with lower embodied energies should be utilised. When considering the detail of design and within engineering appraisal, the carbon associated with construction materials should be considered, for example its source, distance to be transported, method of transport and volume. Where reasonable lower carbon alternatives are available they should be considered.

Construction waste generation on site should be minimised (where transport off-site would be required) in order to limit carbon emissions associated with this additional transport requirement.

Where possible, the use of mains electricity to power equipment and plant would be preferential to diesel or petrol powered generators. The potential for renewable energy generation (e.g. solar panels, dedicated wind turbines, ground source heat pumps or biomass boilers) to meet energy needs on site should be considered.

All buildings on site should be designed to the highest standards of energy efficiency, meeting or exceeding future Building Standards requirements, and should be well adapted to future climate. Designing in low carbon energy provision and energy efficiency is more cost effective than retrofitting solutions at a later date and is therefore recommended. Similarly, limiting the need to artificially cool buildings, through good design, is recommended.

Summary of information requirements: More detailed information on the scheme design and the site is required to determine potential climate change effects. A FRA should be undertaken to determine potential flood risk, taking account of climate change (refer to the proposed water mitigation in 5A. Higher Strength Rock).

B. Lower Strength Sedimentary Rock

The potential climate change effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 9A. Higher Strength Rock). No effects in addition to those identified for the higher strength rock type are anticipated.

However, the scale of any effects could differ when compared to the higher strength rock type. In the case of the lower strength sedimentary rock, the transport of surplus excavated rock off-site (refer to Sustainability Theme 7B) is estimated to generate in the region of 47,100 tonnes of CO₂ for the Derived Inventory Reference Case excluding Pu/U and 313,400 tonnes of CO₂ for the Derived Inventory Upper Inventory. Due to the increased volumes of surplus excavated rock requiring removal off-site, CO₂ emissions associated with the transport of surplus excavated rock off-site could be greater for the lower strength sedimentary rock type when compared to the higher strength rock type.

The transport of materials for the construction of the surface-based facilities is estimated to generate in the region of 4,000 tonnes of CO₂ for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory (as the scale of the surface facilities are expected to be the same).

Similarly, the transport of materials for the construction of the underground accesses (drift and shafts) and the common services area is estimated to generate in the region of 300 tonnes of CO₂ and 400 tonnes of CO₂ respectively for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory.

The transport of construction materials for the lower strength sedimentary rock ILW/LLW vaults and HLW/SF disposal tunnels could generate in the region of 13,800 tonnes of CO₂ for the Derived Inventory Reference Case excluding Pu/U and 34,200 tonnes of CO₂ for the Derived Inventory Upper Inventory respectively.



9. Climate Change

B. Lower Strength Sedimentary Rock (cont)

With respect to embodied carbon, for the construction phase the total embodied CO₂ is estimated to be in the region of 302,800 tonnes for the Derived Inventory Reference Case excluding Pu/U and 774,100 tonnes for the Derived Inventory Upper Inventory (taking account of the embodied carbon in the surface facilities, underground accesses (drift and shafts), common services area and ILW/LLW vaults and HLW/SF disposal tunnels).

The embodied CO₂ in the surface-based facilities, drift and shafts and common services area is estimated to be 83,900 tonnes for both the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory (as the scale of the surface facilities are expected to be the same).

The embodied CO₂ in the ILW/LLW vaults and HLW/SF disposal tunnels is estimated to be 218,900 tonnes for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and 690,200 tonnes for the Derived Inventory Upper Inventory respectively.

C. Evaporite Rock

The potential climate change effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 9A. Higher Strength Rock). No effects in addition to those identified for the higher strength rock type are anticipated.

However, the scale of any effects could differ when compared to the higher strength rock type. In the case of the evaporite rock type, the transport of surplus excavated rock off-site (refer to Sustainability Theme 7C) is estimated to generate in the region of 118,700 tonnes of CO₂ for the Derived Inventory Reference Case excluding Pu/U and 327,300 tonnes of CO₂ for the Derived Inventory Upper Inventory. Due to the increased volumes of surplus excavated rock requiring removal off-site, CO₂ emissions associated with the transport of surplus excavated rock off-site could be greater for the evaporite rock type when compared to the higher strength rock type.

The transport of materials for the construction of the surface-based facilities is estimated to generate in the region of 4,000 tonnes of CO₂ for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory (as the scale of the surface facilities are expected to be the same).

Similarly, the transport of materials for the construction of the underground accesses (shafts) and the common services area is estimated to generate in the region of 200 tonnes of CO₂ and 400 tonnes of CO₂ respectively for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory.

The transport of construction materials for the evaporite rock ILW/LLW vaults and HLW/SF disposal tunnels could generate in the region of 11,200 tonnes of CO₂ for the Derived Inventory Reference Case excluding Pu/U and 29,000 tonnes of CO₂ for the Derived Inventory Upper Inventory respectively.

With respect to embodied carbon, for the construction phase the total embodied CO₂ is estimated to be in the region of 260,800 tonnes for the Derived Inventory Reference Case excluding Pu/U and 798,200 tonnes for the Derived Inventory Upper Inventory (taking account of the embodied carbon in the surface facilities, underground accesses (drift and shafts), common services area and ILW/LLW vaults and HLW/SF disposal tunnels).

The embodied CO₂ in the surface-based facilities, drift and shafts and common services area is estimated to be 83,700 tonnes for both the evaporite rock Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory (as the scale of the surface facilities are expected to be the same).

The embodied CO₂ in the evaporite ILW/LLW vaults and HLW/SF disposal tunnels is estimated to be 177,100 tonnes for the evaporite rock Derived Inventory Reference Case excluding Pu/U and 714,500 tonnes for the Derived Inventory Upper Inventory respectively.



9. Climate Change

Headline Issues

- Increase in CO₂ emissions associated with vehicle movements, any use of diesel generators to power plant, and the energy used in facilities and infrastructure (including the embodied energy within construction materials).

For all host rock types, the potential effect of the Derived Inventory Upper Inventory in relation to transport related carbon emissions, and the carbon embodied in construction material, would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in the volume of construction materials required and construction waste generated, and increase in the volume of surplus excavated rock to be removed off-site.

Carbon emissions and the quantities of embodied carbon are, however expected to vary between the different host rock types. CO₂ emissions for the transport of materials for the construction of a GDF are estimated to be greatest for the higher strength rock type (taking account of the transport of materials for the construction of the surface-based facilities, underground accesses, common services area and ILW/LLW vaults and HLW/SF disposal tunnels, and the transport of surplus excavated rock off-site). For the Derived Inventory Reference Case excluding Pu/U construction of a GDF within higher strength rock is estimated to generate approximately 27,800 tonnes of CO₂, compared to 18,500 tonnes of CO₂ for lower strength sedimentary rock, and 15,800 tonnes of CO₂ for evaporite rock. Similarly, for the Derived Inventory Upper Inventory, the higher strength rock type is estimated to generate approximately 61,700 tonnes of CO₂, compared to 38,900 tonnes of CO₂ for the lower strength sedimentary rock type, and 33,600 tonnes of CO₂ for the evaporite rock type.

Similarly, with respect to embodied carbon, total embodied carbon associated with the construction of the buildings, underground accesses (drift and/or shafts), commons services area, ILW/LLW vaults and HLW/SF disposal tunnels is anticipated to be greater for the higher strength rock type when compared to the other host rock types. For the Derived Inventory Reference Case excluding Pu/U the total embodied carbon for higher strength rock is estimated to be approximately 432,500 tonnes of CO₂, compared to 302,800 tonnes of CO₂ for lower strength sedimentary rock, and 260,800 tonnes of CO₂ for evaporite rock. Similarly, for the Derived Inventory Upper Inventory, the total embodied carbon for the higher strength rock type is estimated to be approximately 1,097,500 tonnes of CO₂, compared to 774,100 tonnes of CO₂ for the lower strength sedimentary rock type, and 798,200 tonnes of CO₂ for the evaporite rock type.

10. Noise and Vibration

A. Higher Strength Rock

Assessment of Effects:

Construction activities associated with a GDF are likely to result in perceptible increases in noise. Significant sources of on site noise include drilling and blasting, piling works, earth moving equipment, construction plant, diesel generators, rail traffic and road traffic (HGVs, concrete trucks, forklift trucks, delivery vehicles, vans and personnel vehicles). The construction of the underground facilities, by means of drilling and blasting, and the movement of excavated rock in particular would be a perceptible source of noise, both continuous background noise and intermittent noise. The surface effects of noise and vibration from drilling and blasting are likely to be greater during the initial stages of excavation, reducing as the depth of the excavation increases.

Noise disturbance may also arise from sustained high levels of construction traffic (transport of construction materials and construction wastes, excavated rock and personnel to and from the site) (refer to Sustainability Theme 7). Assuming that construction traffic would have to use local roads (e.g. lower order, B and C roads) and may pass close to sensitive receptors, it is anticipated that there may be a negative noise effect from construction traffic, particularly HGVs, passing along non-primary routes. However, the exact route(s) would depend on the sites location and extent of local receptors.

Activities such as piling works, drilling and blasting and HGV movements may also cause vibration effects. Vibration effects from drilling and blasting would be difficult to quantify until such time as the ground conditions at the site are known, as the nature of the rock at the site needs to be confirmed to determine the level of propagation from the source, ideally through a test blast.

Depending on the proximity of sensitive receptors to the site, there would be the potential for noise and vibration associated with construction activities to have an effect on sensitive receptors (occupants of residential buildings, community and recreational facilities and noise sensitive businesses and enterprises).



10. Noise and Vibration

A. Higher Strength Rock (cont)

Whilst activities on site would generate noise and vibration, any effects from on site noise would probably not be significant due to the need to adhere to the requirements of legislation (Control of Pollution Act, 1974) and best practice set out in BS 5228: 2009 (Code of Practice for Noise and Vibration Control on Construction and Open Sites). Good management of any works would ensure that a breach of limits would be unlikely. However, HGV movements could potentially cause a local noise nuisance.

There would probably not any difference in noise and vibration effects between the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory, due to the need to adhere to the requirements of legislation.

Assumptions and uncertainties: The scale of surface development is assumed to be the same for the different waste inventories. It is assumed that construction material and construction wastes would be transported to and from the site via road, with the exception of excavated rock from the construction of the underground facilities, all of which is assumed to be transported from the site via rail. It is assumed that construction traffic may have to use local roads (e.g. lower order, B and C roads) to reach the site and may pass close to sensitive receptors such as residential areas.

At this stage, no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the site and works to sensitive receptors and the level and extent of noise and vibrations generated.

Proposed Mitigation/Enhancements:

Noise levels at the nearest receptors would need to be agreed with the Local Authority Environmental Health Officer responsible, and would typically be enforced through a Section 61 Agreement under the Control of Pollution Act, which would give prior consent to carry out certain construction works.

Limits would typically be taken from BS 5228: 2009, which specifies a limit of 65dB(A) in quiet areas for airborne noise. Some local authorities advocate noise limits given in MPS2: Controlling and Mitigating the Environmental Effects of Mineral Extraction in England, with equivalents for the rest of the UK, as appropriate for construction projects, and given the nature and duration of the construction works this could be a reasonable requirement. MPS 2 allows for higher noise levels for short periods where working is close to receptors, typically for the construction of noise mitigation such as bunds or screening, but a lower long-term noise limit.

Acceptable levels of noise and vibration at working sites should be defined in Tender documents and monitored constantly to ensure compliance. Strict limits should be placed on the levels of noise and vibration caused by the use of explosives. The appropriate amount of explosives to be used and the denotation sequence should be calculated such that vibration levels are controlled to levels below the maximum permissible level.

BS 5228: 2009 contains a large amount of good practice guidance which should be implemented by the contractor, with the aim of reducing any noise and vibration effects on receptors. The noisiest activities should be limited to daytime periods (including deliveries to site). Good practice measures could include the use of acoustic screening to help to reduce off-site noise; selection of plant systems that generate minimum noise levels; enclosure of noisy plant and equipment within buildings or kiosks, if necessary fitted with acoustic panels; considered placement of equipment away from sensitive receptors; lining of chutes discharging rock with rubber; and use of 'quiet' (Smart) reversing alarms on vehicles.

The use of mains electricity or renewable energy supply in preference to a diesel generator may also help to minimise noise and emissions.

Traffic movements should be controlled by traffic management measures specifying routes and times (e.g. restricting operating hours of large surface vehicles and restricting delivery times to the site) (refer to Sustainability Theme 7A for traffic and transport mitigation).

Summary of information requirements: Detailed site-specific information is required to establish the extent of any effects, particularly the location of the site in relation to sensitive receptors (e.g. residents), and the topography and landscaping of the site, which can affect noise and vibration propagation.

Further information on the proposed scheme design and construction methods, including information on working hours, the likely areas of working and the noise levels of equipment to be used, is also required to enable a more detailed and accurate assessment of the effects to be made.



10. Noise and Vibration

B. Lower Strength Sedimentary Rock

The potential noise and vibration effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 10A. Higher Strength Rock).

In the case of the lower strength sedimentary rock type, the underground facility would be excavated by a combination of tunnel boring machine, road header and drill and blast methods. Noise levels of the different construction techniques vary, with drill and blast methods generating both continuous background noise from drilling, and intermittent low frequency noise from the detonation of explosives. In comparison, tunnel boring machines and road header machines would be a source of continuous background noise at a lower frequency. However, due to the need to adhere to the requirements of legislation there would probably not be any significant difference in effects between the different host rock types.

C. Evaporite Rock

The potential noise and vibration effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 10A. Higher Strength Rock).

In the case of the evaporite rock type, the underground facility would be excavated by continuous miner and/or road header machines. Continuous miners and road headers would be a source of continuous background noise at a lower frequency. However, due to the need to adhere to the requirements of legislation there would probably not be any significant difference in effects between the different host rock types.

Headline Issues

- Potential for noise disturbance and/or vibration effects from surface construction activities (e.g. from earth moving equipment, rail transport, HGVs, concrete trucks, forklift trucks, delivery vehicles, vans, personnel vehicles, cranes and belt conveyors and rock crushing facilities).
- Potential for noise disturbance and vibration effects from underground excavation works (both continuous background noise on a 24hr basis and intermittent noise during blasting).

At this stage, no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the site and works to sensitive receptors and the level and extent of noise and vibrations generated.

There would probably not be any significant difference in noise and vibration effects between the different waste inventories and host rock types, due to the need to adhere to the requirements of legislation.

For the higher strength rock type, it is proposed to excavate the underground facility using drill and blast methods. For the lower strength sedimentary rock type the underground facility would be excavated by a combination of tunnel boring machine, road header and drill and blast methods, and in the case of the evaporite rock type, the underground facility would be excavated by continuous miner and/or road header machines.

As noted in the assessment, the noise levels of the different construction techniques vary, with drill and blast methods generating both continuous background noise from drilling, and intermittent low frequency noise from the detonation of explosives. In comparison, tunnel boring machines, road header machines and continuous miners are likely to be a source of continuous background noise at a lower frequency. However, the use of different techniques would probably not result in any significant difference in disturbance, as specified noise limits for the works would need to be adhered to.

The type of host rock would affect the degree to which vibrations penetrate the rock and affect an area due the rock type's amplification or damping properties. Differences in vibration effects would be difficult to quantify until such time as the ground conditions at the site are known, as the nature of the rock at the site needs to be confirmed to determine the level of propagation from the source.



11. Land Use

A. Higher Strength Rock

Assessment of Effects:

For the higher strength rock type, an approximate surface site area of 1.1km² would be required for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory. As noted in Sustainability Theme 2A, within this surface site area the surface facilities and infrastructure would be constructed (construction support, operational management and administration, workshops and transport related infrastructure). Excavated rock spoil would also be stored within the surface site area arising from the construction of the underground facilities. It is assumed that a capacity of up to 3,589,000m³ would be stored in bunds for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory. In addition, land take outside of the surface site area may also be required for improvements to, or for the development of new rail and/or road transport infrastructure.

The surface site area would be fenced off and inaccessible to the public during construction and once operational. If a greenfield location is selected, there would be the potential for the construction of a GDF to result in a change in existing land use patterns, and construction activities may result in the loss or severance of agricultural or community/recreational land.

The significance of the land take, particularly loss of agricultural or community/recreational land would depend on the quality of the land and the characteristics of the area surrounding the site (i.e. the extent of land of equal value in the surrounding area).

Assumptions and uncertainties: It is assumed for the purposes of this assessment that the site would be greenfield. As such, depending on the grade of the agricultural land, it is assumed that good quality agricultural land (grades 1-3a) could be affected by the development. The surface site area is assumed to be the same for the different waste inventories. It is assumed that the entire area of surface land take would be fenced off and inaccessible to the public from commencement of construction.

It is assumed that the surface site area for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore there would probably not be any significant difference in potential effects on land uses between the different waste inventories.

Proposed Mitigation/Enhancements:

In determining site location, the highest grade of agricultural land should be avoided where possible, particularly where the construction of a GDF would result in severance on a scale that could affect the viability of neighbouring land uses.

Construction of a GDF should aim to minimise the loss of noted landscape features or views (refer to Sustainability Theme 2A for more information).

The extent of land take required should be refined as the design of a GDF develops to allow more accurate assessment of the likely land use effects at the siting stage. Land use requirements should be carefully considered to strike a balance between minimisation of land take (and therefore effects on existing land use and, potentially, land quality) and incorporation of suitable measures required for mitigation or enhancement, notably landscape screening and planting.

Where effects on an existing land use are unavoidable through siting or design, and particularly where the construction of a GDF could affect the viability of businesses on adjacent land, or the loss of agricultural land, compensation or benefits should be provided as appropriate, either financially or through the provision of similar land or alternative premises elsewhere.

Should any public rights of way be affected as a result of construction activities, they should be diverted to allow their continued use wherever possible.

Where possible, consideration should be given to opportunities for enhancement in the local area, for example through the provision of support to local businesses or the use of local businesses for construction activities where relevant.

Summary of information requirements: Site-specific information is required to determine the likelihood of effects on land use. Consideration of existing land uses and their sensitivity would enable the significance of any land take on land uses to be determined and any mitigation identified.



11. Land Use

B. Lower Strength Sedimentary Rock

The potential land use effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 11A. Higher Strength Rock).

No effects to addition to those identified for higher strength rock are anticipated.

Similar to the higher strength rock type, the surface site area for the lower strength sedimentary rock type would be approximately 1.1km². The surface site area would include surface facilities and infrastructure and up to 3,589,000m³ of excavated rock in bunds (for both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory).

C. Evaporite Rock

The potential land use effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 11A. Higher Strength Rock).

Similar to the higher strength rock type, the surface site area for the evaporite rock type would be approximately 1.1km², assuming that the surface site area includes surface facilities and infrastructure and surface screening bunds. In the case of the evaporite rock type none of the excavated rock would be stored in surface bunds within the site, as the excavated rock salt would not be suitable for this. Instead the only excavated rock to be retained on site would be that required for backfilling of the HLW/SF disposal tunnels, shafts and common services area (estimated to be approximately 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory), which would be stored within a suitably designed area. Surface screening bunds would be created using spoil and imported material as required.

Given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types (which propose approximately 3,589,000m³ in bunds on the site), there is the possibility that land take could be less for the evaporite rock type.

Headline Issues

- Potential for the construction of a GDF to have an effect on existing land uses, particularly where land take results in the loss or severance of agricultural land or community/recreational land.

There would probably not be any significant difference in potential land use effects between the different waste inventories and host rock types, as the surface site area is assumed to be the same (approximately 1.1km² for each of the host rock types, assuming that the surface site area for the evaporite rock type includes surface screening bunds).

Notwithstanding this, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that land take could be less for the evaporite rock type.

12. Socio-economics

A. Higher Strength Rock

Assessment of Effects:

Construction would involve the employment of a range of specialist contractors (e.g. site management, civil, mining and electrical engineers, geologists and safety advisors). A proportion of construction jobs, particularly support jobs (e.g. plant operators, crane drivers and security staff) may be immediately suitable for the local workforce, creating opportunities for the employment of local contractors and individuals. Experience from the mining industry provides a comparator for assessing many of the effects.



12. Socio-economics

A. Higher Strength Rock (cont)

Health and Safety regulations on the number of people working, for example in a single shaft, would be a key determinant of the timescales for their construction and the size of the workforce that can be effectively deployed. Ancillary activities, rock crushing and transport of spoil, would as far as possible be sized to handle a steady stream of material. The construction would therefore provide regular employment for activities which can be cost effectively performed by a local workforce.

The NDA estimate that, on average 886 people per year could be employed during the construction phase, of which an estimated 806 people could be directly involved in construction, for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory. Taking account of these aspects and scale and duration of the construction of a GDF, the effects on local employment would be significant and beneficial especially as initial costs, for example training, would be a small proportion of the overall operational expenditure.

A GDF would be a major user and producer of materials and would occupy a significant position within the supply chains of other industries. It has the potential to affect local prices, for example for cement or road aggregates, due to activities resulting directly from construction, but also in local markets used by the workforce.

The construction of a GDF has a number of aspects with socio-economic consequences, amongst these are:

Particular requirements for cutting, drilling and crushing equipment;

Offsetting decreases in technologies such as stabilisation techniques and/or pumping; and

Energy requirements.

The main effects relate to supply chains and are:

Rock specific upstream supply chains (possibly dependant on which part of the world has the best practice for similar operations in that rock type and/or experience in supply of specialist equipment);

Rock specific downstream supply chains (for example, road aggregates, coastal defences, and building materials); and

Potential use of own-supply to avoid hold-up and local monopoly issues.

The surplus excavated rock that would not to be used for backfill or site bunding may be released to the market and could affect wholesale supply prices. The effect of this would be to some extent dependent on the level of demand and availability of supply at the time of arising.

The rock type may provide opportunities for synergy and corresponding economic efficiency benefits. For example, it may meet requirements as a building material which is a sensitive response to local landscape conditions.

Site based staff and visiting contractors would introduce a demand for local accommodation and services. Given the duration of the works, there would be the potential that site based staff may relocate and become resident in an area and, in addition to spending their money in the local economy, may bring families with children who may increase the demand for school places. Visiting staff would require accommodation in local hotels with requirements for different local services, for example taxis and restaurants. It should be noted that a local community in a greenfield/rural setting may be particularly sensitive to the demand created by such activities with potentially both significant positive and negative effects.

There would also be the potential for the construction (and subsequent operation) of a GDF to have a negative effect on the desirability of the surrounding area as a place to live, work and visit. Knock-on effects from a GDF could include a decrease in land value and house prices in the local area due to the presence of the facility, which may be viewed as unfavourable. Construction activities could potentially have a negative effect on the viability of businesses in close proximity (e.g. effects on productivity due to disturbance to staff from noisy activities).

Depending on the location and the proximity of local populations, there may be a negative effect on quality of life from construction activities (e.g. associated with the increase in traffic on the road network, noise, vibration and air quality effects from construction works and traffic), although it is deemed to be uncertain until the location of a GDF is identified. Potential receptors include neighbouring residents, schools and users of community, leisure and recreational facilities, public open space and rights of way. There would also be the potential for construction activities, given the duration of construction, to affect the viability of businesses (e.g. effects on productivity due to disturbance to staff from noisy construction activities).



12. Socio-economics

A. Higher Strength Rock (cont)

Overall, the potential effect of the Derived Inventory Upper Inventory in relation to socio-economic effects could potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility and associated increase in construction period.

Compared to the Derived Inventory Reference Case excluding Pu/U, over the whole time period, the Derived Inventory Upper Inventory would:

Increase the case for dedicated investment in activities at the site but also in the service sector; and

Reduce the need for temporary accommodation and services.

There is not, however, expected to be any increase in employment associated with the Derived Inventory Upper Inventory, as health and safety regulations govern the level of construction activity on site. The annual scale of construction works would therefore not increase, instead the construction period would be longer.

Assumptions and uncertainties: It is assumed for the purposes of this assessment that the site would be greenfield. The scale of surface development is assumed to be the same for the different waste inventories. It is assumed that construction traffic may have to use local roads (e.g. lower order, B and C roads) to reach the construction site and may pass close to sensitive receptors such as residential areas. It is assumed that the level of employment would be the same for the different waste inventories, as the scale of construction works would not increase on an annual basis, instead the construction period would be longer.

The potential socio-economic effects of the construction of a GDF are largely dependent on the proximity of local populations to the construction works, the relationship with the upstream and downstream supply chains, the nature of the local economy and the sensitivity to the character of the effects predicted. As such at this stage the majority of the socio-economic effects are uncertain.

Proposed Mitigation/Enhancements:

Construction and operation of a GDF would be a multi-billion pound project that would provide skilled employment for hundreds of people over many decades. It would contribute greatly to the local economy and wider socio-economic framework. There could be spin-off industry benefits, infrastructure benefits, benefits to local educational or academic resources, and positive effects on local service industries that support the facility and its workforce. It is also likely to involve major investments in local transport facilities and other infrastructure, which would remain after the facility had been closed.

In addition there may be other benefits which may be commensurate with developing the social and economic wellbeing of a community that has decided to fulfill such an essential service to the nation. A community benefits package would be agreed such that the overall balance of benefits and any perceived detriments would reflect the needs of local communities and their future generations. Indeed, the UK Government acknowledges that siting of the facility raises other issues, some of them intergenerational, and an approach needs to be identified that recognises and addresses the potential effect on a community over the long timescales involved. Accepting that delivery mechanisms to achieve this would be developed as discussions progress, the following could be some of the overarching objectives for the investment that a community might benefit from as a result of hosting a GDF:

Improved local training/skills development/education investment

Increased business for local service industries

Improved public services/infrastructure/housing/ recreational facilities

Improved transport infrastructure

Better local healthcare to meet the increased needs of the community

Local environmental improvement

This list is illustrative rather than exhaustive as short and long-term local needs may vary depending on the community that hosts the facility. As potential host communities and Community Siting Partnerships work with the NDA's delivery organisation and UK Government they would begin a dialogue about the local needs arising from hosting a GDF. Ultimately the community and UK Government would need to agree on the final arrangement.



12. Socio-economics

A. Higher Strength Rock (cont)

Any opportunities to employ local contractors and individuals for construction or for the use of local materials and suppliers should be identified, although due consideration and adherence to local employment legislation is required (e.g. no discrimination on any grounds). As such it may be difficult to offer employment opportunities exclusively to local people. Any potential to offer training opportunities (e.g. apprenticeship schemes) should be pursued.

Developing dedicated facilities on site, such as cement production, can help to mitigate the negative effects such as large scale use of a road network. Water borne transport of heavy materials such as aggregates mitigates against energy costs and promotes a low carbon solution.

Particularly as a result of its position on supply chains, a GDF is likely to be exposed to markets with average price increases above inflation and which experience substantial volatility. Stabilising these prices through financial hedging instruments and other mitigating strategy should be investigated as part of the development, to avoid negative socio-economic effects.

Any increase in demand for services and accommodation arising from construction of a GDF, and its potential effect on the existing community, should be considered carefully.

Where possible, consideration should be given to opportunities for enhancement in the local area through the provision of improved or additional facilities or services, particularly where demand for such services would increase as a result of the construction works. Care should be taken to consider the effects and requirements of the community with respect to factors such as opportunities for access to services, facilities, leisure, recreation, education, training and housing. It should be noted that the use of hotels/guesthouses could have a greater positive effect on the local economy, as a result of indirect and secondary effects, than renting houses for construction workers, which may increase the price for the local population.

Should construction works affect public rights of way, these should be diverted to allow their continued use wherever possible. Similarly, effects on amenity value should be minimised as far as possible (refer to Sustainability Theme 2A).

Consideration should be given to opportunities for enhancement, such as improvements to the public rights of way network (e.g. in terms of usability, surfacing or routing).

Close consultation with the local community regarding potential improvements/enhancements is recommended to help ensure that local needs and wants are met.

Summary of information requirements: Site-specific information is required to establish the extent of any effects, particularly the location of the site in relation to local communities, markets and sensitive receptors (e.g. residents). Further information on the proposed scheme design and construction methods is also required to enable a more detailed and accurate assessment of the effects on supply chains and markets to be made. The opinions of local communities should be sought when appropriate to identify appropriate guidelines defining behaviour for staff and contractors when in the local community.

B. Lower Strength Sedimentary Rock

The potential socio-economic effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 12A. Higher Strength Rock).

However, the scale of any effects could differ when compared to the higher strength rock type due to the host rock type and construction techniques. Due to its low commercial value, any potential effects associated with the release of surplus excavated lower strength sedimentary rock to the market could be less when compared to the higher strength rock type.

There would also be a greater requirement for specialist equipment for the lower strength sedimentary rock type, including the use of tunnel boring and road header machines, along with drill and blast techniques for the construction of the underground facility.



12. Socio-economics

C. Evaporite Rock

The potential socio-economic effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 12A. Higher Strength Rock).

However, the scale of any effects could differ when compared to the higher strength rock type due to the host rock type and construction techniques. The potential resource value of evaporite rock may result in the surplus excavated rock affecting the markets that use evaporites (e.g. road grit and cement production) by causing an oversupply of such product. This could have potentially negative effects on the existing suppliers of such products.

There would also be a greater requirement for specialist equipment for the evaporite rock type when compared to the higher strength rock, including the use of continuous miner and/or road header machines for the construction of the underground facility.

Headline Issues

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- Potential for a proportion of jobs to be suitable for the local workforce, creating opportunities for the employment of local contractors and individuals.
- Potential for site based staff and visiting contractors to introduce a demand for local accommodation and services.

There would probably not be any significant difference in employment opportunity between the different host rock types. Fewer construction staff would be required to operate tunnel boring machines, road headers and continuous miners in comparison to drill and blast. However these would be specialist jobs and therefore would not have any significant effect on potential local employment opportunities.

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- Potential for the construction of a GDF, as a major user and producer of materials, to affect supply chains and local prices.
- Potential for a GDF to have a negative effect on the desirability of the surrounding area as a place to live, work and invest, with potential for negative effects on local land values and house prices.
- Potential for construction activities to have a negative effect on the quality of life of local populations (e.g. the increase in traffic on the road network, noise, vibration and air quality effects from construction works and traffic).

For all of the host rock types, construction activities for the Derived Inventory Reference Case excluding Pu/U would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility. The potential effect of the Derived Inventory Upper Inventory could therefore be greater than that of the Derived Inventory Reference Case excluding Pu/U.

There would be the potential for surplus excavated higher strength and evaporite rock released into the market to affect the markets, for example wholesale supply prices, particularly the markets that use evaporites (e.g. road grit and cement production). Due to its low commercial value, any potential effects associated with the release of surplus excavated lower strength sedimentary rock to the market could be less when compared to the other host rock types. Although this is to some extent dependent on the level of demand and availability of supply at the time of arising. There would also be the potential for the requirement of significant volumes of construction materials to affect the markets; however the potential effects cannot be ascertained at this stage. There would be a greater requirement for specialist equipment for the lower strength sedimentary rock and evaporite rock types (i.e. tunnel boring machines, road headers and continuous miners) when compared to the higher strength rock type.

There would be the potential for construction activities to have a negative effect on the quality of life of local populations (e.g. associated with the increase in traffic on the road network, noise, vibration and air quality effects from construction works and traffic). There would also be the potential for a GDF to have a negative effect on the desirability of the surrounding area as a place to live, work and invest. Knock-on effects from a GDF could include a decrease in land value and house prices in the local area due to the presence of the facility, which may be viewed as unfavourable. Construction activities could potentially have a negative effect on the viability of businesses in close proximity (e.g. effects on productivity due to disturbance to staff from noisy activities).

At this stage, no site has been selected and subsequently the potential for effects on quality of life, business productivity and desirability of the area is uncertain. The potential for effects would depend on the proximity of the sites and works to sensitive receptors and the level and extent of any disturbance.



13. Health and Well-being

A. Higher Strength Rock

Assessment of Effects:

Depending on the location of the site and the proximity of local populations, construction activities could have a negative effect on health and well-being (e.g. disturbance from noise and vibrations, and air quality effects from works and traffic). Potential receptors include on site staff and visitors, neighbouring residents, schools and users of community, leisure and recreational facilities, open space and rights of way.

Depending on the type of higher strength rock, there may be a risk to human health from drilling and blasting activities associated with the release and chronic inhalation of silica dust from silicate rich rocks (e.g. granite), which depending on the extent of exposure can cause silicosis, an incurable lung disease. Without adequate dust controls, there is the potential for workers to develop accelerated silicosis over a period of 5-10 years. Notwithstanding this, any potential risk to health can be prevented by following appropriate dust prevention and health and safety procedures.

Construction of a GDF may be used as a focus for anti nuclear sentiment and may be subject to protest action from opposition groups and local communities. This may potentially increase the fear of crime through the fear of vandalism and personal injury as a result of an influx of a large number of people into a local area. However, the use of a transparent, partnership and voluntarism approach to site selection should help to minimise the risk of such action.

There may be some beneficial effects on well-being due to the implementation of a community benefits package.

Construction activities for the Derived Inventory Upper Inventory would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility. The potential effects of the Derived Inventory Upper Inventory on health and well-being could therefore be greater than that of the Derived Inventory Reference Case excluding Pu/U.

Assumptions and uncertainties: The scale of surface development is assumed to be the same for the different waste inventories. It is assumed that construction traffic may have to use local roads (e.g. lower order, B and C roads) to reach the construction site and may pass close to sensitive receptors such as residential areas. The potential for construction activities to affect health and well-being depends on the location of the site and its proximity to sensitive receptors (e.g. residents).

At this stage no site has been selected and subsequently the potential for effects on health and well-being is uncertain. The potential for effects depends on the proximity of the site and construction activities to sensitive receptors and the extent of any disturbance. At this stage it is uncertain to what extent there would be active opposition to facility construction.

Proposed Mitigation/Enhancements:

Surface facilities and support infrastructure should be sited as far as possible from site boundaries remote from potential sensitive receptors and any works that have the potential to have an effect on health and well-being (e.g. noisy and dust generating activities) should take place within enclosed areas wherever possible.

Measures to control emissions of dust, vehicle emissions and other discharges from the site, as well as noise and vibration levels should be implemented (refer to Sustainability Themes 8A, 7A, 5A and 10A respectively).

Overall dust exposure should be controlled by minimising dust around the work area. Engineering controls (local exhaust ventilation) and containment methods (blast-cleaning machines and cabinets) should be installed to prevent dust from being released into the air. Workers should be provided with the appropriate Personal Protective Equipment (PPE) (e.g. air supplied respirators under high dust conditions) where necessary to avoid breathing dusts and informed about the health effects of silica dust and good working practices that reduce dust. Vacuums with high-efficiency particulate air (HEPA) filter or wet-sweeping should be used.

Transport routing strategies should be implemented in order to avoid, as far as possible, sensitive receptors (refer to Sustainability Theme 7A).

Contractors registered with the Considerate Constructors Scheme, who commit to best practice construction methods, should be employed where possible.

Close consultation and full exchange of information with the local community, liaison with the local police and authorities and the use of appropriate on site security should minimise the risk of negative consequences of protest action, such as an increase in fear of crime. This may be achieved through the use of relevant community forums.



13. Health and Well-being

A. Higher Strength Rock (cont)

The use of prescriptive guidelines for staff and contractor behaviour within nearby settlements should be considered in line with the opinions of local residents to minimise disruption or inconvenience perceived and develop good working relationships through liaison.

Summary of information requirements: Further information is required on the proximity of the site to sensitive receptors, and the proposed scheme design and construction methods, to identify the likely effects in more detail.

B. Lower Strength Sedimentary Rock

The health and well-being effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 13A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The health and well-being effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 13A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- Potential for construction activities to have a negative effect on health and well-being.
- Potential for the construction of a GDF to be subject to protest action from opposition groups and local communities.

For all of the host rock types, construction activities for the Derived Inventory Upper Inventory would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility. The potential effects of the Derived Inventory Upper Inventory on health and well-being could therefore be greater than that of the Derived Inventory Reference Case excluding Pu/U.

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As noted in the assessment, chronic inhalation of silicate rich rock over a prolonged time period (5 to 10 years) can cause silicosis. There is the potential for silicate to be present within all of the rock types; however the silica content of higher strength rock could potentially be greater than evaporite or lower strength sedimentary rock. Notwithstanding this, due to the need to adhere to health and safety legislation, there would probably not be any significant difference in potential effects between the different host rock types.

At this stage no site has been selected and subsequently the potential for effects on health and well-being is uncertain. The potential for effects depends on the proximity of the site and construction activities to sensitive receptors and the extent of any disturbance. At this stage it is uncertain to what extent there would be active opposition to facility construction.

14. Safety

A. Higher Strength Rock

Assessment of Effects:

The construction works, particularly drilling and blasting activities are likely to pose a number of significant hazards to the on site workforce and visitors to the site. Potential major hazards include: collision and impact hazards (e.g. involving plant, vehicles and personnel); explosion and detonation (e.g. associated with the use of explosives); exposure to substances hazardous to health (e.g. contact with cement and dusts); entrapment, asphyxiation, and loss of ventilation (e.g. associated with underground works); electrical hazards (e.g. electrical shock from live cables); and other occupational hazards such as working at height and manual handling. However, although there would be many potential risks, any risk would have been identified and managed through the contractor(s) compliance with health and safety legislation and risk management procedures. As such, the potential effect would probably not be significant.



14. Safety

A. Higher Strength Rock (cont)

The construction works would be unlikely to present a significant risk to the public (i.e. local communities) provided access to the site was restricted and the relevant health and safety procedures were in place. Although any increase in traffic movements associated with construction could potentially increase the risk of road traffic accidents.

It is assumed that construction activities for the Derived Inventory Reference Case excluding Pu/U would be similar in scale to the Derived Inventory Upper Inventory, as health and safety regulations govern the level of construction activity on site and therefore the scale of the work would not increase, instead the construction period would be longer. Therefore there would probably not be a significant difference in potential safety effects between the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory. However, the length of time involved may increase the statistical chance of accidents occurring.

Assumptions and uncertainties: It is assumed that the staff undertaking the works would not be subjected to any higher degree of risk than if they undertook such activities elsewhere as they would be professionally trained and should understand the risks of the activities which they practice.

Proposed Mitigation/Enhancements:

A focus on implementing a safety culture should be adopted to reduce the risks to construction workers and local communities. Relevant legislation and best practice guidance should be adhered to and requirements exceeded where possible. Full implementation of Construction, Design and Management Regulations would apply to all works irrespective of scale or duration.

Contractors registered with the Considerate Constructors Scheme should be employed for the construction works where possible, who commit to best practice construction methods. Appropriate contractors with a shared commitment to safety, compatible with the Nuclear Decommissioning Authority's own mission statement, could be identified during the tendering process by recognising staff safety experience, safety records and safety procedures through the weightings given to the tender evaluation process.

Site activities should be reviewed by an independent examiner to ensure that hazards are appropriately addressed. Where required, detailed method statements from contractors along with proof of permits to work, safe systems of working and sufficiently suitably qualified and experienced personnel should be obtained before issuing a contract.

Site access should be restricted as appropriate and all personnel on site to be inducted/briefed, to wear appropriate PPE and to be accompanied by another member of staff as necessary to help to reduce accidents. Third parties may be protected from any increase to the risk of health and safety through adequate protection around the construction site to prevent the public from entering the area.

Appropriate routing of construction traffic (refer to Sustainability Theme 7A) may help to reduce the risks of traffic accidents.

Ensure the safe storage of spoil and excavated rocks to exclude any safety risk.

Summary of information requirements: Further information is required on the proximity of the site to sensitive receptors, and the proposed scheme design and construction methods, to identify the likely effects in more detail. In particular, the exposure of sensitive receptors to hazards associated with normal construction activities as well as accident and emergency situations should be considered.

B. Lower Strength Sedimentary Rock

The effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 14A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 14A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.



14. Safety

Headline Issues

- Risk to human health and safety from construction activities.
- Potential for an increased risk of road traffic accidents associated with any increase in traffic movements.

For all of the host rock types, it is assumed that construction activities for the Derived Inventory Reference Case excluding Pu/U would be similar in scale to the Derived Inventory Upper Inventory, as health and safety regulations govern the level of construction activity on site and therefore the scale of the works would not increase, instead the construction period would be longer. Therefore there would probably not be a significant difference in potential safety effects between the different waste inventories. However, the length of time involved may increase the statistical chance of accidents occurring.

There would probably not be any significant differences in potential effects between the different host rock types, due to the need to adhere to the requirements of legislation.

15. Waste

A. Higher Strength Rock

Assessment of Effects:

The construction of a GDF would generate large amounts of construction wastes. The key primary waste materials would be aggregates of varying size and composition, and soil and spoil.

For the higher strength rock type, the most significant waste stream would be excavated rock from the construction of the underground facilities. The construction of a GDF would require large volumes of hard rock to be excavated; approximately 5,225,000m³ for the Derived Inventory Reference Case excluding Pu/U and 13,800,000m³ for the Derived Inventory Upper Inventory. For the higher strength rock type it is proposed that up to 3,589,000m³ of the excavated rock would be used to construct surface bunds around the site. In addition, 1,190,000m³ of excavated rock for the Derived Inventory Reference Case excluding Pu/U, and 3,010,000m³ of excavated rock for the Derived Inventory Upper Inventory, would be used as backfill material for backfilling the HLW/SF disposal tunnels (which would take place during the operational phase). For both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory, a further 263,771m³ and 296,308m³ is also estimated to be required for the backfilling of the drift and shafts, and common services area respectively (which would take place during the closure phase).

In the case of the Derived Inventory Reference Case excluding Pu/U, all of the higher strength rock excavated would be utilised on site. For the Derived Inventory Upper Inventory, not all of the excavated rock would be utilised on site. The surplus excavated rock, estimated to be approximately 6,640,921m³ for the Derived Inventory Upper Inventory, would be taken off-site. However, the potential exists for the beneficial use of the waste excavated rock to be removed off-site (such as use for aggregates), which would significantly reduce the waste excavated rock requiring disposal.

There would be a possibility that some excavated rock may contain contaminants from drilling and blasting, in which case it may require treatment on site or disposal to a suitable facility off-site in accordance with the relevant waste guidance.

Secondary wastes arising from construction activities would include:

Concrete, gypsum and other rendering materials;

Water from dust prevention, rock cutting and washing;

Dusts that accumulate from blasting / cutting;

Woods and metals (supporting members, reinforcing screens and bolts);

Plastics (membrane films and piping off-cuts used for drainage and seepage protection);

Packaging (blown foam, plastic ties, metal ties, wooden crates, pallets); and

Waste oils and drilling fluids.



15. Waste

A. Higher Strength Rock (cont)

Tertiary wastes could include broken bricks/blocks, nails/bolts, worn tools, canisters, drums (e.g. fuel, diesel, chemicals) and food waste and food packaging from on site food consumption.

It is also expected that there would be some increase in general office waste from the construction support facilities such as paper, organic canteen waste, packaging and possibly some electrical waste from the replacement and upgrades of computers/printers or other electrical products. The average waste figures for UK Government indicate that around 0.45 tonnes of waste is generated per employee.

Depending on their type, wastes may be sent to landfill, recycled or re-used, for example, as landscaping or as aggregates for construction projects. Drilling fluid is anticipated to be mechanically filtered and treated on site to remove sediment load. Depending on the fluid used, it may be recycled, discharged or removed for further off-site treatment. Some of the waste (some drilling fluid, small amounts of laboratory waste) may be treated as hazardous waste and would need to be handled in compliance with relevant waste regulations.

The potential effect of the Derived Inventory Upper Inventory in relation to waste would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased GDF size, with an associated increase in the volume of construction materials required and construction waste generated, and due to the generation of surplus excavated rock to be removed off-site.

Assumptions and uncertainties: As a detailed scheme design and construction methods have not been finalised, at this stage specific quantities of likely waste arisings and the extent of any re-use or recycling cannot be determined.

Proposed Mitigation/Enhancements:

Best practice waste minimisation and management practices should be implemented, with a focus on materials resource efficiency (using less and re-using more), in accordance with WRAP guidance, *Delivering Effective Waste Minimisation* and *Delivering Good Practice Waste Management*.

Materials usage and waste should be considered early in the design process to minimise resource use and reduce the quantity of waste before it arises on site. This should involve early discussions between the client, designers, contractors, subcontractors and designers to identify potential waste streams and their quantities.

Opportunities to 'design out waste' should be considered. This could involve: design with existing resources (taking account of resources available on site or close by); standardisation of building form, layout and materials; design for easy demolition, re-construction and adaptability; designing to material dimensions; use of made-to-measure materials; and the use of modern methods of construction (that eliminate or reduce the requirement for site cutting and handling of materials). Where there is the potential for long-term use of a building, a high quality of design and flexibility should be adopted to allow for future use. Further guidance on waste minimisation through design is provided in the WRAP document, *Achieving Effective Waste Minimisation through Design: Guidance on designing out waste for construction clients, design teams and contractors*.

The use of products and materials with good practice levels of recycled content and inherently lower embodied carbon (relative to other products meeting the same specification), or those with low environmental impact (e.g. those that are A-rated in the Green Guide specification) should be specified. AggRegain, the free sustainable aggregates information service provided by the WRAP Aggregates Programme (<http://www.aggregain.org.uk/>), provides a lot of useful information and advice on sourcing sustainable aggregates.

Construction materials that are compatible with recycling or ease of re-use should be utilised where possible. Provision should be made for the segregation of wastes to enable a high level of recycling. Options for re-use of materials on site should be identified. Where re-use and recycling is not possible, options for disposal should be investigated to minimise environmental effects.

Best practice procedures for the protection, storage and handling of materials should be followed. A robust logistics plan should be developed, identifying how materials are to be moved to, from and on site and how they are stored. This could include just in time delivery or the use of consolidation centres to help reduce damage to materials and products by minimising the amount of time stored on site, and take back schemes for surplus material.

The potential for materials wastage should be reduced through effective procurement; producing accurate estimates of materials required, ordering the correct amount of materials at the correct time, developing partnerships with suppliers who can implement waste minimisation at source; and setting up schemes with suppliers to take back surplus materials.



15. Waste

A. Higher Strength Rock (cont)

A waste minimisation strategy should be implemented as part of the Site Waste Management Plan (SWMP). As a minimum, the SWMP should contain detailed measures to comply with relevant waste legislation but should also include good practice guidance and objectives in order to maximise the reduction, reuse and recovery of waste, with disposal to landfill as the least preferred option. The waste minimisation strategy should identify where waste arises in design, procurement and logistics and set out clear mechanisms for achieving waste reduction. Further guidance on site waste management is provided in the Department of Trade and Industry document, *Site Waste Management Plans, Guidance for Construction Contractors and Clients* and supplementary guidance available from WRAP (www.wrap.org.uk/construction).

The appointment of trained, experienced and professional contractors would also be beneficial to reducing construction waste generation as they may work more efficiently than those with less experience. Training and educating site staff on how to reduce waste, and the appointment of contractors registered with the Considerate Constructors Scheme may also help to ensure the appropriate management of construction waste, who commit to best practice construction methods.

Summary of information requirements: Further information on the proposed scheme design, construction methods and options for the end use of excavated rock is required to enable a more detailed and accurate assessment of waste arisings to be made. Information on potential uses, markets and demand for waste excavated rock is required to inform the identification of potential options for the re-use of waste excavated rock. Similarly, information on the availability and capacity of waste management facilities in the vicinity of the site would be useful in identifying the best method of managing waste, whilst minimising transportation through the utilisation of local facilities where possible.

B. Lower Strength Sedimentary Rock

The types of waste arisings and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 15A. Higher Strength Rock).

However, the scale of waste arisings would differ when compared to the higher strength rock type. For the lower strength sedimentary rock type, the most significant waste stream would be excavated rock from the construction of the underground facilities; approximately 4,820,000m³ for the Derived Inventory Reference Case excluding Pu/U and 11,775,000m³ for the Derived Inventory Upper Inventory. For the lower strength sedimentary rock type it is proposed that 3,589,000m³ of the excavated rock would be used to construct surface bunds around the site. However the remainder, estimated to be approximately 1,231,000m³ for the Derived Inventory Reference Case excluding Pu/U and 8,186,000m³ for the Derived Inventory Upper Inventory, would be taken off-site.

In the case of the lower strength sedimentary rock type, opportunities for the beneficial re-use of the excavated rock could be limited, as the rock may not have much commercial value.

C. Evaporite Rock

The types of waste arisings and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 15A. Higher Strength Rock).

However, the scale of waste arisings would differ when compared to the higher strength rock type. For the evaporite rock type, the most significant waste stream would be excavated rock from the construction of the underground facilities; approximately 4,273,000m³ for the Derived Inventory Reference Case excluding Pu/U and 11,366,000m³ for the Derived Inventory Upper Inventory. None of the excavated rock would be used to construct surface bunds around the site, as the excavated rock would not be suitable for this. However, a proportion of the excavated rock would be retained on site within a dedicated storage area and used as backfill material, estimated to be around 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory for the backfilling of the HLW/SF disposal tunnels, shafts and common services area.

The remainder, estimated to be approximately 3,100,879m³ for the Derived Inventory Reference Case excluding Pu/U and 8,549,879m³ for the Derived Inventory Upper Inventory, would be taken off-site. However, the potential exists for the beneficial use of the waste excavated rock to be removed off-site, which would significantly reduce waste excavated rock arisings. Halite evaporite rock is used widely in the UK as rock salt for winter de-icing of roads, and for chlorine production, food seasoning and medicinal purposes. Anhydrite is used in cement manufacture (i.e. Portland cement), as a source of sulphur and as a mineral filler in plastics, paints and paper. There is therefore the potential for the beneficial use of the remainder of the excavated rock to be removed off-site.



15. Waste

Headline Issues

- Generation of significant volumes of waste excavated rock spoil from the construction of the underground facility.
- Construction and general office waste arisings throughout the construction phase, including some potentially hazardous or special waste material from contaminated materials or testing.

For all host rock types, the potential effect of the Derived Inventory Upper Inventory in relation to waste would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased GDF size, with an associated increase in the volume of construction materials required and construction waste generated, and the increase in the volume of excavated rock to be removed off-site.

The types of wastes generated would be similar for the different host rock types. However, the quantities of waste arisings would vary for the different host rock types. Construction of a GDF within the evaporite rock could generate the greatest quantities of surplus excavated rock to be removed off-site. Construction of a GDF within the evaporite rock for the Derived Inventory Reference Case excluding Pu/U is estimated to generate 3,100,879m³ of excavated rock, compared to 1,231,000m³ for the lower strength sedimentary rock. For the higher strength rock Derived Inventory Reference Case excluding Pu/U, all of the excavated rock would be utilised on site and therefore there would be no surplus excavated rock. Similarly, the construction of a GDF within the evaporite rock for the Derived Inventory Upper Inventory is estimated to generate 8,549,879m³ of excavated rock, compared to 8,186,000m³ for the lower strength sedimentary rock and 6,640,921m³ for the higher strength rock. Notwithstanding this, in the case of the higher strength rock and evaporite rock types, the potential exists for the beneficial use of the waste excavated rock to be removed off-site, which would significantly reduce waste excavated rock arising that would require disposal. Evaporite rock in particular could be of commercial value. In the case of the lower strength sedimentary rock type, opportunities for the beneficial re-use of the excavated rock could be limited due to its low commercial value. The lower strength sedimentary rock type could therefore generate greater volumes of waste excavated rock due to the potential fewer opportunities for re-use. For all of the host rock types, if none of the surplus excavated rock could be re-used off-site for another purpose this would result in a significant waste stream.

16. Resource Use, Utilities and Services

A. Higher Strength Rock

Assessment of Effects:

The construction of a GDF would require the use of large amounts of construction materials. Key construction materials that would be required in significant quantities include:

Concrete: an estimated 173,000m³ and 444,000m³ for the higher strength rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively.

Stainless steel/rock bolts: an estimated 10,500 tonnes and 28,000 tonnes for the higher strength rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively.

Explosives for blasting (estimates of volumes required are currently not available).

Key utilities and services that would be required during the construction period include electricity, water supplies, communications systems, and ventilation systems for construction works underground. This could place additional demand on existing utilities and services, and there may be a requirement for new or additional utilities and services provision.

Throughout the construction period there would probably be an increase in energy use associated with the operation of plant machinery and equipment, site buildings and infrastructure (heating, lighting, canteen facilities and electronics), the operation of ventilation systems to ensure a supply of clean air, and lighting to allow safe working and for security purposes. Diesel generators may be used as a back-up power source but most of the energy demand would be met from the National Grid.

Water would be required for use in construction (e.g. for dust suppression and cleaning machinery) and for domestic purposes such as drinking water and canteen use as well as toilet and washing facilities (refer to Sustainability Theme 5A). Sewerage systems for treatment of wastewater may also be required, depending on whether there would be opportunity to connect to the existing network.



16. Resource Use, Utilities and Services

A. Higher Strength Rock (cont)

The significance of effects would be dependent to some extent on the location of the site, which would in turn dictate the availability of resources, utilities and services, and the sourcing of specific materials and their transport distance. Notwithstanding this, the scale of the proposed scheme is an important factor: the potential effect of the Derived Inventory Upper Inventory would potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in utilities, services and resource use (particularly construction materials).

Assumptions and uncertainties: At this stage no site has been selected and detailed scheme design and construction methods have not been finalised. Therefore, the specific quantities of resources required the availability of resources and the sourcing of specific materials cannot be determined.

Proposed Mitigation/Enhancements:

Consideration should be given to sources of energy and utilities/services such that the effect of increased demand on existing services is taken into account.

Implement best practice waste minimisation and management practices, with a focus on materials resource efficiency (using less and re-using more), in accordance with WRAP guidance, Delivering Effective Waste Minimisation and Delivering Good Practice Waste Management (refer to Sustainability Theme 15A).

The potential for renewable energy generation and use to meet energy needs on site should be considered (e.g. solar panels, dedicated wind turbines, ground source heat pumps and biomass boilers).

All buildings on site should be designed to meet or exceed future Building Standards; this might require achievement of a BREEAM rating of 'very good' and with an aim to achieve 'excellent' where possible. All buildings should be designed to the highest standards of energy and water efficiency, incorporating features such as energy efficient insulation materials, lighting and heating systems and appliances (e.g. double glazing, energy efficient bulbs, 'A' rated white goods and dual low flush toilets); and systems for the collection and recycling of water (e.g. rain water and grey water recycling systems).

Where possible, alternatives means of transport to road should be used for the transport of construction materials and measures to reduce private vehicle use should be implemented (refer to Sustainability Theme 7A). Routing strategies should be implemented for construction material transport in order to reduce fossil fuel use (taking into account other factors such as sensitive receptors and congestion effects). Vehicles and plant used on site should be well maintained and not left running when not in use to minimise fuel consumption.

Summary of information requirements: Further information on the proposed scheme design, construction methods and options for the end use of excavated rock is required to enable a more detailed and accurate assessment of resource use to be made. Information on potential resource markets and demand is required to inform the assessment of effects. Site-specific information is required to determine the existing availability of utilities and services and thus the potential effect of the construction of a GDF on utilities and services provision.

B. Lower Strength Sedimentary Rock

The potential resources required for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 16A. Higher Strength Rock).

However, the scale of resource use would differ when compared to the higher strength rock type. For the lower strength sedimentary rock type, the following quantities of key construction materials are anticipated:

Concrete: an estimated 161,000m³ and 405,000m³ for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively.

Stainless steel/rock bolts: an estimated 21,360 tonnes and 53,720 tonnes for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively.

Explosives for blasting (estimates of volumes required are currently not available).



16. Resource Use, Utilities and Services

C. Evaporite Rock

The potential resources required for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 16A. Higher Strength Rock).

However, the scale of resource use is expected to differ. For the evaporite rock type, the following quantities of key construction materials are anticipated:

Concrete: an estimated 18,000m³ and 435,000m³ for the evaporite rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively.

Stainless/rock bolts: an estimated 21,520 tonnes and 57,656 tonnes for the evaporite rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively.

Headline Issues

- Requirement for significant quantities of construction materials.
- Increase in resource use, utilities and services throughout the construction phase.

For all host rock types, the potential effect of the Derived Inventory Upper Inventory is would potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in utilities, services and resource use (particularly construction materials).

Although the types of resources, utilities and services would be similar for the different host rock types, the extent of resource use would vary between the different host rock types. The higher strength rock type is estimated to require the greatest quantities of concrete, with the evaporite rock type requiring the least. Notwithstanding this, it is noted that generally the structural stability and mechanical strength of higher strength rock would potentially be greater, requiring less stainless steel/rock bolts and thus reducing resource requirements for strengthening. In comparison, in the case of the evaporite rock and lower strength sedimentary rock types a greater level of reinforcement may be required to maintain excavations. It is anticipated that the greatest level of reinforcement would be required for the evaporite rock due to its creep properties, resulting in the usage of greater quantities of stainless steel/rock bolts.

Energy use to power plant could be greater where tunnel boring machines, road headers and continuous miners are utilised, as these machines use more electric power than drill and blast methods. There would also be increased requirements for mobilisation and infrastructure for tunnel boring machines, road headers and continuous miners. Notwithstanding this, construction of a GDF within the higher strength rock may require a greater quantity of plant and machinery which would have to be more hard wearing.



Appraisal of the operation phase

Following construction of underground accesses and the first Intermediate Level Waste (ILW) and Low Level Waste (LLW) vaults, a Geological Disposal Facility (GDF) would enter its operational phase. The key activities throughout the operational phase would be the construction of ILW/LLW vaults and High Level Waste (HLW)/Spent Fuel (SF) disposal tunnels on an “as required” basis, the transport and emplacement of radioactive waste into the waste disposal areas, and the subsequent backfilling of the waste disposal areas.

For all of the host rock types, it has been assumed that all ILW/LLW and HLW/SF would be packaged by the waste producers and that no packaging would take place at a GDF. A summary of the waste disposal programme, and waste buffer and backfill assumptions for GDF concepts for each host rock type is provided below.

Higher strength rock

Waste disposal programme

It is assumed that ILW/LLW disposal would commence from 2040. The disposal rate would be variable over the operational period.

Drift throughput would be a maximum of 3,900 journeys per year. The inlet cell would be located underground and would have a maximum capacity of 2,500 unshielded ILW packages per year.

HLW/SF disposal would commence from 2075 and would be 200 packages per year.

Plutonium (Pu)/Uranium (U) disposal would commence from ~2123 and would be 200 packages per year.

Indicative waste disposal programmes for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory are summarised below.

Derived Inventory Reference Case excluding Pu/U waste disposal programme:

For the Derived Inventory Reference Case excluding Pu/U, it has been assumed that the bulk of the ILW/LLW would arrive at a GDF between 2040 and 2090, although some ILW/LLW waste would continue to arrive between 2090 and 2128.

An initial inlet capacity of 1,500 and drift capacity of 2,000 is assumed up to 2040, increasing to an inlet capacity of 2,500 and drift capacity of 3,900 in 2042. The throughput of ILW/LLW is estimated to average approximately 1,800 packages per year for the first 30 years, decreasing to approximately 1,300 packages per year for the following 20 years. Between 2090 and ~2128 the maximum throughput is estimated to be 500 packages per year.

HLW/SF disposal is assumed to commence from 2075, at least 25 years into the ILW/LLW disposal period, when the first HLW/SF would be scheduled to arrive. HLW/SF disposal is estimated to be up to 200 packages per year, and therefore would take some 48 years.



Derived Inventory Upper Inventory waste disposal programme:

For the Derived Inventory Upper Inventory, it has been assumed that the bulk of the ILW/LLW would arrive at a GDF between 2040 and 2123. Between 2040 and 2123 the throughput is estimated to average some 2,504 packages per year.

It has been assumed that HLW/SF disposal would commence from 2075, with an estimated throughput of approximately 200 packages per year, which would take some 61 years.

Disposal of Pu/U would be scheduled after the disposal of HLW/SF, which, at a disposal rate of approximately 200 packages per year would take an estimated 30 additional years to dispose of. The disposal of new build SF would take an additional 31 years at the same throughput rate.

Buffering and backfilling

The ILW/LLW vaults would be backfilled and sealed using Nirex Reference Vault Backfill (NRVB). Approximately 1,000,000 m³ of NRVB would be required for the disposal of the Derived Inventory Reference Case excluding Pu/U and approximately 2,300,000m³ of NRVB would be required for the disposal of the Derived Inventory Upper Inventory.

HLW/SF would be buffered using pre-compacted bentonite, formed in a dedicated plant on the surface. To dispose of all the HLW/SF in the deposition holes for the Derived Inventory Reference Case excluding Pu/U, approximately 204,000m³ of bentonite buffer would be required. For the Derived Inventory Upper Inventory, the quantity of bentonite buffer required to fill the deposition holes would increase to approximately 656,000m³.

The HLW/SF disposal tunnels would be backfilled using crushed rock and bentonite. To backfill all of the HLW/SF disposal area disposal tunnels for the Derived Inventory Reference Case excluding Pu/U, approximately 1,700,000m³ of material (crushed rock and bentonite in a 70:30 mix) would be required. For the Derived Inventory Upper Inventory, the quantity of material required would increase to approximately 4,300,000m³. However, it is assumed that crushed rock from the excavation process would meet HLW/SF disposal tunnel crushed rock backfilling requirements. The amount of material required is 1,190,000m³ of crushed rock and 510,000m³ of bentonite for the Derived Inventory Reference Case excluding Pu/U, and 3,010,000m³ of crushed rock and 1,290,000m³ of bentonite for the Derived Inventory Upper Inventory.

In the case of the higher strength rock type, the ILW/LLW vaults would be backfilled on the emplacement of all of the ILW/LLW within a GDF. The backfilling of the HLW/SF disposal tunnels would take place when all deposition holes are filled in a particular tunnel.



Lower strength sedimentary rock

Waste disposal programme

It is assumed that ILW/LLW waste disposal would commence from 2040. The disposal rate would be variable over the operational period.

Drift throughput would be a maximum of 3,900 journeys per year. The inlet cell would be located underground and would have a maximum capacity of 2,500 unshielded ILW packages per year.

HLW/SF disposal would commence from 2075 and would be 200 packages per year.

Pu/U disposal would commence from 2123 and would be 200 packages per year.

Indicative waste disposal programmes for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory are summarised below.

Derived Inventory Reference Case excluding Pu/U waste disposal programme:

For the Derived Inventory Reference Case excluding Pu/U, it is anticipated that the bulk of the ILW/LLW would arrive at a GDF between 2040 and 2090, although some ILW/LLW waste would continue to arrive between 2090 and 2128.

An initial inlet capacity of 1,500 and drift capacity of 2,000 is assumed up to 2040, increasing to an inlet capacity of 2,500 and drift capacity of 3,900 in 2042. The throughput of ILW/LLW is estimated to average approximately 1,800 packages per year for the first 30 years, decreasing to approximately 1,300 packages per year for the following 20 years. Between 2090 and ~2128 the maximum throughput is estimated to be 500 packages per year.

The HLW/SF disposal areas is assumed to commence in 2075, at least 25 years into the ILW/LLW disposal period, when the first HLW/SF would be scheduled to arrive. HLW/SF disposal is estimated to be up to 200 packages per year, and therefore would take some 48 years.

Derived Inventory Upper Inventory waste disposal programme:

For the Derived Inventory Upper Inventory, it has been assumed that the bulk of the ILW/LLW would arrive at a GDF between 2040 and 2123. Between 2040 and 2123 the throughput is estimated to average some 2,504 packages per year.

It has been assumed that HLW/SF disposal would commence in 2075, with an estimated throughput of approximately 200 packages per year, which would take some 61 years.

Disposal of Pu/U would be scheduled after the disposal of HLW/SF, which, at a disposal rate of approximately 200 packages per year would take an estimated 30 additional years to dispose of. The disposal of new build SF would take an additional 31 years at the same throughput rate.



Buffering and backfilling

The ILW/LLW vaults would be buffered and backfilled using NRVB. Approximately 1,050,000m³ of NRVB would be required to buffer and backfill for the Derived Inventory Reference Case excluding Pu/U and approximately 2,540,000m³ of NRVB would be required to buffer and backfill for the Derived Inventory Upper Inventory.¹⁹

HLW/SF disposal tunnels would be buffered using bentonite blocks, formed in a dedicated plant on the surface. The HLW/SF disposal tunnels would then be backfilled using bentonite, carried out progressively as the disposal canisters and bentonite buffer is placed.

To dispose of all the HLW/SF in the disposal tunnels with the appropriate volume of bentonite (blocks and backfill) for the Derived Inventory Reference Case excluding Pu/U, approximately 257,000m³ of bentonite would be required. For the Derived Inventory Upper Inventory, the quantity of bentonite required would increase to approximately 731,000m³.²⁰

In the case of the lower strength sedimentary rock type, backfilling of the ILW/LLW vaults and HLW/SF disposal tunnels would take place as each ILW/LLW vault or HLW/SF disposal tunnel is filled.

Evaporite rock

Waste disposal programme

It is assumed that ILW/LLW waste disposal would commence from 2040. The disposal rate would be variable over the operational period.

The inlet cell would be located underground and have a maximum capacity of 2,500 unshielded ILW packages per year.

HLW/SF disposal would commence from 2075 and would be 200 packages per year.

Pu/U disposal would commence from ~2123 and would be 200 packages per year.

Indicative waste disposal programmes for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory are summarised below.

Derived Inventory Reference Case excluding Pu/U waste disposal programme:

¹⁹ Please note that the NRVB volumes provided are combined figures for buffer and backfill

²⁰ Please note that the bentonite volumes provided are combined figures for buffer and backfill



For the Derived Inventory Reference Case excluding Pu/U, it is anticipated that the bulk of the ILW/LLW would arrive at a GDF between 2040 and 2090, although some ILW/LLW waste would continue to arrive between 2090 and 2128.

An initial inlet capacity of 1,500 and shaft capacity of 2,000 is assumed up to 2040, increasing to an inlet capacity of 2,500 and shaft capacity of 3,900 in 2042. The throughput of ILW/LLW is estimated to average approximately 1,800 packages per year for the first 30 years, decreasing to approximately 1,300 packages per year for the following 20 years. Between 2090 and ~2128 the maximum throughput is estimated to be 500 packages per year.

The HLW/SF disposal areas is assumed to commence in 2075, at least 25 years into the ILW/LLW disposal period, when the first HLW/SF would be scheduled to arrive. HLW/SF disposal is estimated to be up to 200 packages per year, and therefore would take some 48 years.

Derived Inventory Upper Inventory waste disposal programme:

For the Derived Inventory Upper Inventory, it has been assumed that the bulk of the ILW/LLW would arrive at a GDF between 2040 and 2123. Between 2040 and 2123 the throughput is estimated to average some 2,504 packages per year.

HLW/SF disposal is planned to commence in 2075, with an estimated throughput of approximately 200 packages per year, which would take some 61 years.

Disposal of Pu/U would be scheduled after the disposal of HLW/SF, which, at a disposal rate of approximately 200 packages per year would take an estimated 30 additional years to dispose of. The disposal of new build SF would take an additional 31 years at the same throughput rate.

Buffering and backfilling

As the ILW/LLW waste packages are placed, sacks of Magnesium Oxide (MgO) would be placed on top of the waste package stack as the waste is progressively placed. Some 144,000m³ of MgO buffer material would be required for the Derived Inventory Reference Case excluding Pu/U and 356,000m³ of MgO buffer material would be required for the Derived Inventory Upper Inventory.

In the case of the evaporite rock type, due to the nature of the host evaporite rock, there would not be any requirement for backfilling of the ILW/LLW vaults. Instead the strata would be allowed to creep into the ILW/LLW vaults to fill any voids.

The HLW/SF disposal tunnels would be buffered and backfilled using crushed rock salt, and would be carried out progressively as canisters are placed. Volumes of crushed rock required for buffering of the HLW/SF are not available at this stage. However, to dispose of all the HLW/SF in the disposal tunnels approximately 872,000m³ of crushed rock salt backfill material would be required for the Derived Inventory Reference Case excluding Pu/U and 2,516,000m³ for the Derived Inventory Upper Inventory. However, it is assumed that crushed rock from the excavation process would meet HLW/SF disposal tunnel crushed rock salt backfilling requirements.



Table D3 Appraisal of the operation phase

1. Policies and Planning	
A. Higher Strength Rock	
<p>Assessment of Effects:</p> <p>A GDF would fulfil a number of policy and legislative commitments at international and national level; according with the principles of the International Atomic Energy Agency Action Plan and the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, and meeting UK Government requirements for the long-term management of radioactive wastes in accordance with the Managing Radioactive Wastes Safely Programme. A GDF would also contribute towards fulfilling national sustainable development and waste management policies and strategies.</p> <p>However, it is acknowledged that the operation of a GDF could be associated with a significant carbon footprint, which if not matched by corresponding reductions elsewhere in the UK economy could detract from the UK meeting its obligations under the Climate Change Act 2008 (refer to Sustainability Theme 9).</p> <p>The effect of the Derived Inventory Reference Case excluding Pu/U on policy requirements would be the same as those identified for the Derived Inventory Upper Inventory.</p> <p>Assumptions and uncertainties: The operation phase is the next stage in fulfilling policy and legislative commitments for the long-term management of radioactive wastes and is therefore assumed to have a positive effect.</p> <p>Proposed Mitigation/Enhancements:</p> <p>All operational activities should adhere to relevant legislation and best practice guidance. Where possible minimum requirements should be exceeded as should any planning conditions relating to planning permission for the works.</p> <p>Summary of information requirements: It is assumed that any relevant local planning policies (e.g. within the relevant Local Development Framework or equivalent) would have been identified at the construction phase.</p>	
B. Lower Strength Sedimentary Rock	
<p>The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (1A. Higher Strength Rock).</p> <p>No effects in addition to those identified for the higher strength rock type are anticipated.</p>	
C. Evaporite Rock	
<p>The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (1A. Higher Strength Rock).</p> <p>No effects in addition to those identified for the higher strength rock type are anticipated.</p>	
Headline Issues	
+	<ul style="list-style-type: none"> - A GDF would support UK Government commitments for the long-term management of radioactive wastes in accordance with the Managing Radioactive Wastes Safely Programme. <p>Operational activities would have to accord with a range of legislation, policies and requirements. Any relevant regional and local planning policies would need to be adhered to.</p> <p>There would not be any significant differences in effects between the different host rock types and waste inventories, as all of the proposed host rock types would meet policy requirements.</p>



2. Landscape and Visual

A. Higher Strength Rock

Assessment of Effects:

For the higher strength rock type, the surface site area is assumed to be approximately 1.1km² for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory (including surface facilities and infrastructure and up to 3,589,000m³ of excavated rock stored in bunds). Assuming that all operation activities would take place within the surface site area, no further land take is anticipated at the operation phase.

As identified in the construction phase assessment there would be the potential for the surface development to have a negative landscape and visual effect (i.e. changes in landscape character and alterations to, or loss of existing views). Once a GDF becomes operational, the surface facilities and infrastructure, access tunnels (drift and shafts) and the first ILW/LLW vaults would have been constructed, reducing construction works on site and any negative landscape and visual effects associated with these construction works (e.g. the loss of landscape elements or features in the footprint of development, alterations to the landscape character and the introduction of new visual elements into existing views or the loss of key views).

However, the surface facilities and infrastructure would remain on site for the duration of the operational phase, and therefore any negative landscape or visual effect associated with the physical presence of these would remain throughout operation. In addition, surface activities associated with the construction of the ILW/LLW vaults and HLW/SF disposal tunnels (i.e. the storage and movement of excavated rock), which would take place concurrently with disposal throughout the operational phase, could continue to have a negative visual effect. Should surface operational activities extend outside of the surface site area there may be the potential for additional effects. There would be the potential for surface operational activities, in particular movement of material and the delivery and emplacement of radioactive waste to have a negative visual effect. However, it is assumed that the majority of these operations would be contained within the surface buildings and the underground facility, and would therefore have no visual effect additional to that already considered as part of the construction phase.

Lighting for operational, safety and security purposes would be required throughout the operational period, resulting in light pollution. The effects of lighting would be similar to that of the construction phase.

Notwithstanding the above, by the operational phase it is assumed that the initial surface bunds would have been constructed and that any visual screening and enhancements implemented during construction would have become more established. These measures could help to reduce visibility into the site and thus help to reduce any landscape and visual effect. This assumes that further excavated rock would be stored on the inner side of the surface bunds with backfill material being removed from the inner side of the bunds. Although it should be noted that, depending on their scale and nature, surface bunds could also present a landscape and visual effect (i.e. where the surface bunds are extensive and may not be well integrated with the landscape surrounding the site).

No further negative landscape and visual effects are anticipated with respect to the development of, or improvements to, the rail or local road network during the operational phase, as any new infrastructure or improvements to existing infrastructure are assumed to take place during the construction phase. Similarly, no significant effects are anticipated from the transport of radioactive waste by sea, assuming that existing ports are utilised. However, should new port infrastructure be required, the landscape and visual effect of this would need to be assessed.

Assumptions and uncertainties: The surface site area and the scale of surface development is assumed to be the same for the different waste inventories. It is assumed that all construction materials, machinery, construction waste (with the exception of excavated rock) and backfill material would be transported to and from the site via road. All surplus rock excavated from the construction of the underground facilities is assumed to be transported off-site via rail. Two transport scenarios have been considered for the transport of radioactive wastes; rail (the Road/Rail scenario, which assumes a 70:30 rail and road split), and sea (the Sea/Road/Rail scenario, which assumes an 80:10:10 sea, rail and road split). If radioactive waste was transported by sea, it is also assumed that existing port facilities would be utilised (i.e. no new sea transport infrastructure development would be required).

At this stage no site has been selected and subsequently the scale of effect of the operational phase in landscape and visual terms is uncertain. The scale of any effect would be dependant on the scale and nature of the development, the surrounding landscape and topography, degree of urbanisation and extent of screening.

It is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore there would probably not be a significant difference in potential landscape and visual effects between the different waste inventories.



2. Landscape and Visual

A. Higher Strength Rock (cont)

However, as noted in the assessment it is assumed that any visual screening and enhancements implemented during construction would have become more established, which could reduce visibility into the site and thus help to reduce any negative landscape and visual effects. Although it should be noted that, depending on their scale and nature, surface bunds could also have a negative landscape and visual effect (i.e. where the surface bunds are extensive and may not be characteristic of the landscape surrounding the site).

Proposed Mitigation/Enhancement: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 2A of the construction phase assessment.

Landscape mitigation and enhancements should be progressed and a maintenance plan put in place for the long-term management and upkeep of landscaped areas (taking account of water and biodiversity aspects – refer to Sustainability Themes 5A and 6A).

Excavated rock from surface bunds that would be used for backfilling should be removed from the inside of the site to preserve the visual integrity of the surface bunds, when viewed from locations outside the site.

Should new port infrastructure be required for the transport of radioactive waste by sea, the landscape and visual effect of this would need to be assessed.

Summary of information requirements: No further information in addition to that identified for the construction phase has been identified (refer to the construction phase assessment for 3A. Higher Strength Rock).

B. Lower Strength Sedimentary Rock

The potential landscape and visual effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 2A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.

Similar to the higher strength rock type, the surface site area for the lower strength sedimentary rock type is assumed to be approximately 1.1km². The surface site area would include surface facilities and infrastructure and up to 3,589,000m³ of excavated rock in bunds (for both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory).

C. Evaporite Rock

The potential landscape and visual effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 2A. Higher Strength Rock).

Similar to the higher strength rock type, the surface site area for the evaporite rock type would be approximately 1.1km², assuming that the surface site area includes surface facilities and infrastructure and surface screening bunds. In the case of the evaporite rock type none of the excavated rock would be stored in surface bunds within the site, as the excavated rock salt would not be suitable for this. Instead the only excavated rock to be retained on site would be that required for backfilling of the HLW/SF disposal tunnels, shafts and common services area (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory), which would be stored within a suitably designed area. Surface screening bunds would be created using spoil and imported material as required.

Given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types (which propose approximately 3,589,000m³ in bunds on the site), there is the possibility that surface disturbance could be less for the evaporite rock type.



2. Landscape and Visual

Headline Issues

- Potential for surface infrastructure and activities, and lighting on site to have a continued negative visual effect (e.g. effects on surrounding landscape character and existing views).

There would not be any significant difference in potential landscape and visual effects between the different waste inventories and host rock types, as the surface site area is assumed to be the same (approximately 1.1km² for each of the host rock types, assuming that the surface site area for the evaporite rock type includes surface screening bunds).

Notwithstanding this, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type.

3. Cultural Heritage

A. Higher Strength Rock

Assessment of Effects:

No significant effects on above ground cultural heritage and archaeological sites and features within the site, or on traditional activities, are anticipated as a result of operational activities, as no further surface disturbance or development in addition to that during the construction phase is anticipated. This is assuming a surface site area of approximately 1.1km², including surface facilities and infrastructure, and up to 3,589,000m³ of excavated rock stored in bunds. However, should surface operational activities extend outside of the development footprint for the construction phase there may be the potential for negative effects.

The construction phase assessment identified that there would be the potential for surface development to have a negative effect on the setting and amenity of above ground historic or archaeological features and landscapes. Once completed, the surface facilities and infrastructure would remain on site for the duration of the operational phase, and therefore any effects associated with the physical presence of surface development would remain throughout operation. However, it is expected that any visual screening and enhancements implemented during construction would have become more established, which could help to reduce visibility into the site and thus help to reduce any negative effects on the setting and amenity of nearby cultural heritage resources (refer to Sustainability Theme 2A).

There would be the potential for surface operational activities, in particular movement of material and the delivery and emplacement of radioactive waste, to have a negative effect on the setting and amenity of above ground historic or archaeological features and landscapes. Although, it is assumed that the majority of these operations would be contained within the surface buildings and the underground facility. As noted above, any visual screening and enhancements could also help to reduce visibility in to the site.

No significant effects on subsurface and buried archaeological remains are anticipated as a result of operational activities, as although vaults and disposal tunnels would be constructed throughout the operational period (on a 'just in time' basis), these excavations would be within the host rock at depths of at least 500m, where there would be very limited potential for archaeological remains.

There would be the potential for pollution from engine exhausts and vibration associated with any increase in rail traffic or road traffic (particularly Heavy Goods Vehicles (HGVs) in the case of road traffic) (refer to Sustainability Theme 7A) to have a negative effect on historic or archaeological features (e.g. listed buildings) by accelerating corrosion and weathering.

No significant effects are anticipated from the transport of radioactive waste by sea, assuming that existing ports are utilised. However, should new port infrastructure be required for the transport of radioactive waste by sea, the cultural heritage and archaeological effect of this would need to be assessed.

Assumptions and uncertainties: The surface site area and the scale of surface development is assumed to be the same for the different waste inventories. It is assumed that all construction materials, machinery, construction waste (with the exception of excavated rock) and backfill material would be transported to and from the sites via road.



3. Cultural Heritage

A. Higher Strength Rock (cont)

All of the surplus rock excavated from the construction of the underground facilities is assumed to be removed off-site via rail. If radioactive waste was transported by sea, it is also assumed that existing port facilities would be utilised (i.e. no new sea transport infrastructure development would be required).

It is assumed that the site surface area and scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore there would probably not be a significant difference in potential cultural heritage effect associated with surface activities between the different waste inventories.

At this stage no site has been selected and subsequently the predicted effects of operational activities on cultural heritage and archaeology is uncertain. The scale of any effect would depend on the proximity of activities to any cultural heritage and archaeological sites and features and landscapes, the current condition and sensitivity of the site/feature/landscape affected and the level of disturbance or loss.

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 3A of the construction phase assessment. Refer to the landscape and visual mitigation identified in Sustainability Theme 2A for mitigation that could reduce potential effects on the setting and amenity of above ground historic or archaeological features and landscapes.

Summary of information requirements: No further information in addition to that identified for the construction phase has been identified (refer to the construction phase assessment for 3A. Higher Strength Rock).

B. Lower Strength Sedimentary Rock

The potential effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 3A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.

Similar to the higher strength rock type, the surface site area for the lower strength sedimentary rock type is assumed to be approximately 1.1km², including surface facilities and infrastructure and up to 3,589,000m³ of excavated rock stored in bunds.

C. Evaporite Rock

The potential effects of the evaporite rock type on cultural heritage and archaeology that could occur, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 3A. Higher Strength Rock).

Similar to the higher strength rock type, the surface site area for the evaporite rock type is assumed to be approximately 1.1km². However, for the evaporite rock type the surface site area would include a dedicated storage area for excavated rock (approximately 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) and surface screening bunds.

Given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types (approximately 3,589,000m³ in bunds on the site for the higher and lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type.

Headline Issues

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- Potential for operational activities to have a negative effect on the setting and amenity of above ground historic or archaeological features and landscapes.
- Potential for pollution and vibrations associated with rail or road traffic to have a negative effect on historic or archaeological features.

There would probably not be any significant difference in potential effects on visible above ground cultural heritage or archaeological features between the different waste inventories and different host rock types, as the surface site area is assumed to be the same (approximately 1.1km², assuming that the surface site area for the evaporite rock type includes surface screening bunds).



3. Cultural Heritage

Headline Issues (cont)

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Notwithstanding this, as noted in the construction phase assessment, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for both waste inventories), there is the possibility that surface disturbance could be less for the evaporite rock type.

At this stage no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of activities to any cultural heritage and archaeological sites, features and landscapes, the current condition and sensitivity of the site/feature/landscape affected and the level of disturbance or loss.

4. Geology and Soils

A. Higher Strength Rock

Assessment of Effects:

No significant effects on soil reserves are likely to occur as a result of operational activities as no further site clearance works or disturbance to soils are anticipated during the operational phase. However, should surface operational activities extend outside of the surface site area for the construction phase there may be the potential for effects.

There would be the potential for some of the operational activities such as the transport of construction materials, radioactive wastes and backfill material on site to introduce some low level contamination to the local environment (including, for example, silty water, drill fluid and oil spillages). This risk could be sufficiently mitigated against following best practice guidance, and would therefore be negligible.

Once a GDF became operational, the surface facilities and infrastructure, surface bunds, drift, shafts and the first vaults would have been constructed, reducing construction works on site and therefore no further effects associated with these works are anticipated. However, construction of the vaults and disposal tunnels would probably take place concurrently with disposal throughout the operational phase.

As noted in the construction phase assessment, the construction of a GDF would require large volumes of rock to be excavated: approximately 5,225,000m³ for the Derived Inventory Reference Case excluding Pu/U and 13,800,000m³ for the Derived Inventory Upper Inventory. For the higher strength rock type it is proposed that up to 3,589,000m³ of the excavated rock would be used to construct surface bunds within the surface site area. In addition, 1,190,000m³ of excavated rock for the Derived Inventory Reference Case excluding Pu/U, and 3,010,000m³ of excavated rock for the Derived Inventory Upper Inventory, would be used as backfill material for backfilling the HLW/SF disposal tunnels throughout the operational phase. For both waste inventories, a further 263,771m³ and 296,308m³ is also estimated to be required for the backfilling of the drift and shafts, and the common services area respectively (which would take place during the closure phase). In the case of the Derived Inventory Reference Case excluding Pu/U, all of the excavated rock would be utilised on site and therefore none would need to be taken off-site. For the Derived Inventory Upper Inventory, not all of the excavated rock would be utilised on site. The surplus excavated rock, estimated to be 6,640,921m³ for the Derived Inventory Upper Inventory, would be taken off-site.

Once a GDF becomes operational no significant effects on sites of recognised importance for their geological value (e.g. SSSI or RIGS) are anticipated as a result of operational activities, as no further surface disturbance or development in addition to that during the construction phase would be anticipated. However, should surface operational activities extend outside of the development footprint for the construction phase there may be the potential for negative effects on such sites.

As noted in the construction phase assessment, there would be the potential for the construction of the facility within higher strength rock to have an effect on minerals resources or minerals reserves (refer to 4A. Higher Strength Rock of the construction phase assessment). In addition, in the case of the higher strength rock type, significant quantities of bentonite (refer to Sustainability Theme 16A) would also need to be imported for the backfilling of the HLW/SF disposal tunnels, which could also have an effect on minerals resources and reserves elsewhere. However, for the higher strength rock type the use of some of the crushed rock from the construction of the underground facilities for backfilling of the HLW/SF disposal tunnels, underground access (drift and shafts) and common services area would negate the need to import crushed rock for backfilling of these areas, which could otherwise affect aggregates supply elsewhere. The potential also exists for the beneficial use of surplus excavated rock to be removed off-site (such as use for aggregates).



4. Geology and Soils

A. Higher Strength Rock (cont)

The potential effect of the Derived Inventory Upper Inventory on sites of geological importance and minerals resources or reserves could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility footprint, which could affect a greater area. The footprint of the underground facility for the higher strength rock type is assumed to be at least 4.3km² for the Derived Inventory Reference Case excluding Pu/U and 9.8km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). The magnitude of effect would be potentially high given the area and volume of rock affected and the duration of the effect. However, the significance would be dependent on the quality and type of excavated rock, its availability and its usage.

The physical presence of radioactive waste packages within the disposal tunnels would be unlikely to have any effect on the physical stability or the background level of seismicity of the surrounding geology. There would be some potential risk to waste container integrity from structural failures (e.g. rock falls). However, sufficient rock support of a high standard would be provided to ensure long-term structural stability. Phasing construction of the disposal tunnels, keeping the vaults open for relatively short periods of time, and backfilling would also provide long-term support. In addition, hydrostatic pressure resistant lining would be used where necessary to prevent groundwater ingress.

There would be the potential for heat from the high level radioactive wastes to damage engineered barriers, backfill and host geology. However, the waste disposal areas would be designed to ensure, as far as possible, that waste temperatures would not exceed specifications. The waste packages would also be designed to ensure they retained their integrity for many hundreds of years. The behaviour of corrosive products at the interface between the steel canister and backfill require further investigation. Consequently the effects are uncertain at this stage.

Assumptions and uncertainties: It is assumed that sufficient rock support of a high standard would be provided to ensure the long-term structural stability of the host rock and that the waste packages would be designed to retain their structural integrity.

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 4A of the construction phase assessment.

Summary of information requirements: It is anticipated that the periodic mapping/inspection undertaken during each construction cycle would provide the necessary information to determine the effects and subsequent mitigation required.

B. Lower Strength Sedimentary Rock

For the lower strength sedimentary rock type, the potential effects that could occur and the potential mitigation/enhancements relating to soils and the physical and chemical stability of the host rock are considered to be the same as those identified for higher strength rock (refer to 4A. Higher Strength Rock).

However, as noted in the construction phase assessment, the scale of any effects associated with excavated rock could differ when compared to the higher strength rock type. In the case of the lower strength sedimentary rock the construction of a GDF would require approximately 4,820,000m³ of host rock to be excavated for the Derived Inventory Reference Case excluding Pu/U and 11,775,000m³ for the Derived Inventory Upper Inventory. In the case of lower strength sedimentary rock, it is proposed that approximately 3,589,000m³ of the excavated rock would be used to construct surface bunds around the site. The remainder of the excavated rock, estimated to be approximately 1,231,000m³ for the Derived Inventory Reference Case excluding Pu/U and 8,186,000m³ for the Derived Inventory Upper Inventory, would be taken off-site. None of the excavated rock spoil would be used for backfilling, as the excavated lower strength sedimentary rock would not be suitable for this.

The potential effect of the lower strength sedimentary rock type on sites of geological importance could be greater when compared to the other host rock types, due to the increased size of the underground facility footprint. It is assumed to be at least 7.8km² for the Derived Inventory Reference Case excluding Pu/U and 19.5km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). The construction of the underground facility within the lower strength sedimentary rock would probably not have a significant effect on minerals resources or reserves, due to its low commercial value. However, similar to the higher strength rock type, in the case of the lower strength sedimentary rock type, significant quantities of bentonite (refer to Sustainability Theme 16B) would need to be imported for the backfilling of the HLW/SF disposal tunnels, which could have an effect on minerals resources and reserves elsewhere. Although a smaller quantity of bentonite would be required for this purpose when compared to higher strength rock.



4. Geology and Soils

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 3A. Higher Strength Rock).

However, as noted in the construction phase assessment the scale of any effects associated with excavated rock could differ when compared to the higher strength rock type. In the case of the evaporite rock the construction of a GDF would require approximately 4,273,000m³ of evaporite rock to be excavated for the Derived Inventory Reference Case excluding Pu/U and 11,366,000m³ for the Derived Inventory Upper Inventory.

In the case of the evaporite rock type, none of the excavated rock would be stored in bunds within the surface site area, as the excavated rock would not be suitable for this. However, a proportion of the excavated rock would be retained on site within a dedicated storage area and used as backfill material (estimated to be around 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory for the backfilling of the HLW/SF disposal tunnels, shafts and common services area).

The remainder, estimated to be approximately 3,100,879m³ for the Derived Inventory Reference Case excluding Pu/U and 8,549,879m³ for the Derived Inventory Upper Inventory, would be taken off-site. Evaporite rock can be of commercial value: halite in particular is used widely in the UK as rock salt for winter de-icing of roads, and for chlorine production, food seasoning and medicinal purposes. Anhydrite is used in cement manufacture (i.e. Portland cement), as a source of sulphur and as mineral filler in plastics, paints and paper. There is therefore the potential for the beneficial use of the remainder of the excavated rock to be removed off-site.

The potential effect of the evaporite rock type on sites of geological importance and minerals resources or reserves could be greater when compared to the higher strength rock type, due to the increased size of the underground facility footprint. The underground facility footprint for the evaporite rock type is assumed to be at least 6.5km² for the Derived Inventory Reference Case excluding Pu/U and 18.4km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). Therefore a greater area could be affected.

Headline Issues

-	<ul style="list-style-type: none"> - Potential for operation phase activities to have an effect on soil resources. - Generation of large volumes of surplus excavated rock requiring removal off-site (with the associated effects on transport, nuisance, waste and resources).
?	<ul style="list-style-type: none"> - Potential for the underground facility within the higher strength rock and evaporite rock to result in the continued sterilisation of a minerals resource, or minerals reserve where a site is covered by valid planning permissions for the extraction of minerals. - Potential for excavations into rock and the emplacement of radioactive wastes to affect the physical or chemical stability of the surrounding geology. <p>As noted in the construction phase assessment, in the case of the higher strength rock and evaporite rock types the construction of the underground facility could also result in the sterilisation of a mineral resource or reserve. The evaporite rock type could potentially have the greatest effect, due to the increased size of the underground facility footprint when compared to the higher strength rock type. However, in the case of the higher and evaporite rock types, the use of some of the excavated rock for backfilling (the excavated rock retained on site is likely to meet crushed rock HLW/SF disposal tunnel, drift and/or shaft and common service area backfilling requirements) would negate the need to import crushed rock for backfilling for these purposes, which could otherwise affect mineral resources supply elsewhere.</p> <p>The potential also exists for the beneficial use of surplus excavated rock to be removed off-site, particularly the evaporite rock halite, which is used widely in the UK as rock salt for winter de-icing of roads, for chlorine production, for food seasoning and for medicinal purposes. Although the underground facility for the lower strength sedimentary rock type would have the greatest footprint, this type would be unlikely to have a direct effect on mineral resources or mineral reserves, due to its low commercial value.</p>



4. Geology and Soils

Headline Issues

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However, during the operational phase in the case of higher strength rock and the lower strength sedimentary rock, significant quantities of bentonite (refer to Sustainability Theme 16) would also need to be imported for the backfilling of the HLW/SF disposal tunnels, which could have an effect on minerals resources and reserves elsewhere. The potential effect of the higher strength rock type on minerals resources or reserves associated with the import of bentonite could be greater than that of the lower strength sedimentary rock type, as a greater quantity of bentonite would be required for this purpose when compared to the lower strength sedimentary rock type. The evaporite rock type would potentially have the least effect on minerals resources or reserves associated with the import of backfill material, as only MgO would need to be imported for this purpose.

As noted in the construction phase assessment, excavations into the host rocks could affect the physical or chemical stability of the surrounding geology. However, there would probably not be a significant difference in potential physical stability effects between the different host rock types, as a stable geological environment is essential and the necessary rock support would be provided.

5. Water

A. Higher Strength Rock

Assessment of Effects:

Similar to the construction phase, water would be required throughout the operational phase for use in vault and disposal tunnel construction activities (including, for example, cement mixing, drilling fluid, cleaning machinery and cooling equipment); for routine processes such as wash-down and decontamination; and for potable purposes such as drinking water and canteen use, as well as toilet and washing facilities and laundering protective clothing. In addition, a reliable and adequate water storage and distribution system would be required for fire fighting. Depending on local water resource availability and demand at the site, there would be the potential for water use to affect the availability of water for other licensed water abstractors within the catchment, or for environmental flow targets to be adversely affected. This would be assessed in the determination of any new abstraction licenses by the Environment Agency (EA) or equivalent regulator.

Operational activities would generate several sources of water requiring discharge, including surface run-off; foul water; effluent from groundwater inflow, de-humidification operations and decontamination processes. Any discharges have the potential to affect the water quality and/or rate of flows of receiving waters. Surface run-off could contain contaminants released through spillage of materials such as chemicals and fuels. Drilling activities associated with the ongoing construction of the ILW/LLW vaults and HLW/SF disposal tunnels may also introduce contaminants to groundwater sources (e.g. drilling fluid), and water used as drilling fluid is likely to have a high sediment load, which could affect water quality if discharged untreated. The drill and blast methods for construction of the ILW/LLW vaults and HLW/SF disposal tunnels could produce fracture zones in the rock which act as conduits for groundwater, and hence the possibility of groundwater contamination from these excavations. However, in the host rock, inflows would be reduced.

Typically groundwater effluent would be treated and discharged to surface water or by injection back into an aquifer formation following treatment. Assuming water is discharged back to the aquifer following treatment there is unlikely to be any significant net loss to the groundwater system; the rate of any groundwater ingress to the excavated areas following excavation would be low.

The presence of the underground facility within the host rock, and any grouting/lining in the drift, shafts and tunnels as required, would reduce the transmissive capacity of water bearing formations (aquifers) on a localised scale, acting as a barrier to normal flow patterns. Throughout the operational phase, groundwater flows would require monitoring and control by engineered systems, which may include the diversion of flows to specific collection or drainage points, and storage, monitoring and treatment of the effluent.

It is assumed that the potential effect of a GDF for the Derived Inventory Upper Inventory on groundwater could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows and may result in greater levels of dewatering. The footprint of the underground facility for the higher strength rock type is assumed to be at least 4.3km² for the Derived Inventory Reference Case excluding Pu/U and 9.8km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area).

No further effects relating to flood risk in addition to those identified in the construction phase assessment for the higher strength rock type, are anticipated, as no further site preparation and levelling and surface construction is anticipated and it is assumed that appropriate pollution prevention measures and a suitable surface drainage system for the collection of rainwater would have been provided.



5. Water

A. Higher Strength Rock (cont)

However, should surface operational activities extend outside of the development footprint for the construction phase there may be the potential for flood risk effects due to changes to surface drainage patterns and any increase in impermeable surface areas, which could affect run-off rates and flow pathways.

No significant effects on water quality are anticipated from the transport of radioactive waste by sea, assuming that existing ports and purpose built ships would be utilised, and the necessary precautions are taken. However, it should be noted that there could be the potential for a serious pollution incident where a tanker gets into difficulty (i.e. runs aground or capsizes), resulting in the spillage of oil or radioactive waste.

Should new port infrastructure be required for the transport of radioactive waste by sea, the potential for effects on water quality would need to be assessed.

Assumptions and uncertainties: It is assumed that the host rock in which a GDF is to be constructed would be a minor or non aquifer. However this would need to be assessed when each particular site location is determined.

It is assumed that all construction materials, machinery, construction waste (with the exception of excavated rock) and backfill material would be transported to and from the site via road. All of the surplus excavated rock from the construction of the underground facilities is assumed to be transported off-site via rail. Two transport scenarios have been considered for the transport of radioactive wastes; rail (the Road/Rail scenario, which assumes a 70:30 rail and road split), and sea (the Sea/Road/Rail scenario, which assumes an 80:10:10 sea, rail and road split). If radioactive waste was transported by sea, it is also assumed that existing port facilities would be utilised (i.e. no new sea transport infrastructure development would be required).

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 5A of the construction phase assessment.

Should new port infrastructure be required for the transport of radioactive waste by sea, the potential effect of this would need to be assessed.

Summary of information requirements: It is anticipated that the periodic mapping/inspection undertaken during each construction cycle would provide the necessary information to determine the effects and subsequent mitigation required.

B. Lower Strength Sedimentary Rock

The potential effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 5A. Higher Strength Rock).

However, the scale of any effects associated with excavated rock could differ when compared to the higher strength rock type.

In addition to the potential effects for the higher strength rock, there is the potential that low strength sedimentary rocks may contain sufficient sulphide to cause acid generating reactions on exposure to air and water, giving rise to the potential for contamination of soils and surface watercourses with low pH waters. This potential effect could be mitigated by limiting exposure to air and water by establishing surface bunds quickly and in dry conditions, and by the rapid covering of excavated rock with spoil. Depending on the acid-generating potential, the excavated rock may also need to be sat on impermeable bases and run-off managed to reduce the potential for leachate. Further information is required to determine the potential for effects and subsequent mitigation required.

The footprint of the underground facility for the lower strength sedimentary rock type would be greater than that of the other host rock types. It is assumed to be at least 7.8km² for the Derived Inventory Reference Case excluding Pu/U and 19.5km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). The potential effect of a GDF within the lower strength sedimentary rock on groundwater could therefore be greater than that of the other host rock types due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows and may result in greater levels of dewatering.



5. Water

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 5A. Higher Strength Rock).

However, the scale of any effects associated with excavated rock could differ when compared to the higher strength rock type.

In addition to the potential effects for the higher strength rock type, depending on the evaporite host rock type, any excavated host rock stored on the surface could present a potential pollution risk. The evaporite rock type halite is highly soluble in fresh water, and therefore if excavated halite rock were to come into contact with water the potential would exist for the contamination of surface water courses with high chloride waters. This could be mitigated for by storage under cover. The evaporite rock anhydrite, however, is less so, and therefore the pollution risk would be less than that of halite. Notwithstanding this, once in the underground facility the crushed rock backfill material is not anticipated to have any effect on groundwater, as crushed rock backfill material would be used, which is the same as the host rock.

Permeability varies by rock type; within evaporite rock migration pathways are virtually absent. However, the footprint of the underground facility for the evaporite rock type would be greater than that of the higher strength rock type. The underground facility footprint for the evaporite rock type is assumed to be at least 6.5km² for the Derived Inventory Reference Case excluding Pu/U and 18.4km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). The potential effect of a GDF within the lower strength sedimentary rock type on groundwater could therefore be greater than that of the higher strength rock type due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows and may result in greater levels of dewatering.

Headline Issues

- Increase in water use throughout the operational phase, which has the potential to affect water availability for other licensed abstractors, or for environmental flow targets to be adversely affected.
- Potential for operational activities to affect water quality and/or the rate of flows of receiving waters.

For all three host rock types, the potential effect of the Derived Inventory Upper Inventory on groundwater could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows and may result in greater levels of dewatering.

There is the potential for the different host rock types to affect the scale of any effects on water resources and flood risk. In the case of lower strength sedimentary rock and evaporite rock (depending upon its type), due to the nature of these host rock types, there is the potential for excavated rock stored within the surface site area to negatively affect water quality. Lower strength sedimentary rock may contain sufficient sulphide to cause acid generating reactions on exposure to air and water, giving rise to the potential for contamination of soils and surface water courses with low pH waters. Similarly, the evaporite rock type halite is highly soluble in fresh water and therefore if excavated halite rock were to come in contact with water the potential would exist for the contamination of surface watercourses with high chloride waters. The evaporite rock anhydrite, however, is less so, and therefore the pollution risk would be less than that of halite.

As noted in the construction phase assessment, permeability varies by rock type, with a greater potential for faults and fracturing within the higher strength rock. The assumed lower strength sedimentary rock has minimal fracturing, and within evaporite rock migration pathways are virtually absent. However, as the selection of a suitable host environment would be based on low groundwater flows and at any suitable site the potential for significant groundwater ingress would be low. Notwithstanding this, the lower strength sedimentary rock type could potentially have the greatest effect on groundwater flows as the underground facility footprint of (7.8km² and 19.5km² for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively) would be greater when compared to the higher strength rock type (4.3km² and 9.8km² for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively) and evaporite rock type (6.5km² and 18.4km² for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively).



6. Biodiversity, Flora and Fauna

A. Higher Strength Rock

Assessment of Effects:

Assuming that all operational activities would take place within the surface site area, there would be no further land take during the operational phase. Therefore no further effects on biodiversity are anticipated as a result of land take (i.e. direct loss or fragmentation of habitat to hard engineering). However, should surface operational activities extend outside of the surface site area for the construction phase (assumed to be approximately 1.1km², including surface facilities and infrastructure, and up to 3,589,000m³ of excavated rock stored in bunds) there would be the potential for effects.

The greatest potential effect of the operation of a GDF on biodiversity would probably be the disturbance or displacement of conservation notable species from the site area and its surrounds. Disturbance or displacement of fauna is likely to be caused by a range of factors such as noise (particularly intermittent blasting), human presence and light pollution, and has the potential to reduce the rates of breeding success and survival resulting in detectable falls in the size of local populations of fauna.

The potential for accidental release or spillage of substances (e.g. diesel) and for silt laden run-off to escape into the surrounding environment also has the potential to affect notable flora and fauna, as does the increased deposition of pollutants associated with heavy traffic movements. There is also the potential for indirect effects to occur from the movement and eventual disposal of rock off-site (such as vehicle activity through an area or at the place of disposal).

No significant effects on biodiversity are anticipated from the transport of radioactive waste by sea, assuming that existing ports and purpose built ships are utilised, and the necessary precautions are taken. However, should new port infrastructure be required for the transport of radioactive waste by sea, the potential for effects on biodiversity would need to be assessed.

Assumptions and uncertainties: The surface site area and the scale of surface development is assumed to be the same for the different waste inventories. It is assumed that all construction materials, machinery, construction waste (with the exception of excavated rock) and backfill material would be transported to and from the site via road. All of the surplus rock from the construction of the underground facilities is assumed to be transported off-site via rail. If radioactive waste was transported by sea, it is assumed that existing port facilities would be utilised (i.e. no new sea transport infrastructure development would be required).

It is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore there would probably not be a significant difference in potential biodiversity effects between the different waste inventories.

At this stage, no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the biodiversity value of the site and its surrounds, the sensitivity of any habitats/species present, and the level of habitat disturbance or loss.

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 6A of the construction phase assessment.

Habitat creation or biodiversity enhancements should be progressed and a maintenance plan put in place for the long-term management of habitats.

Summary of information requirements: No further information in addition to that identified for the construction phase has been identified (refer to the construction phase assessment for 6A. Higher Strength Rock).

B. Lower Strength Sedimentary Rock

The potential effects on biodiversity that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer 6A. Higher Strength Rock).

No effects or mitigation in addition to that identified for the higher strength rock type are anticipated.

Similar to the higher strength rock type, the surface site area for the lower strength sedimentary rock type is assumed to be approximately 1.1km², which would include surface facilities and infrastructure, and up to 3,589,000m³ of excavated rock stored in bunds.



6. Biodiversity, Flora and Fauna

C. Evaporite Rock

The potential effects on biodiversity that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 6A. Higher Strength Rock).

Similar to the higher strength rock type, the surface site area for the evaporite rock type is assumed to be approximately 1.1km². However, in the case of the evaporite rock type, the surface site area would include surface facilities and infrastructure, a dedicated storage area for excavated rock (approximately 1,172,121m³ and 2,816,121m³ for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively) and surface screening bunds.

However, although the surface site area is assumed to be 1.1km², given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types (approximately 3,589,000m³ in bunds on the site for the higher and lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type, which could reduce any potential effects on biodiversity.

Headline Issues

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- Potential for the disturbance/displacement of conservation notable species from the sites and their surrounds as a result of operational activities (e.g. such as noise, human presence and light pollution).

There would probably not be any significant difference in potential effects on biodiversity between the different waste inventories, as the surface site area is assumed to be the same (approximately 1.1km², assuming that the surface site area for the evaporite rock type includes surface screening bunds). However, as noted in the construction phase assessment, although the surface site area is assumed to be 1.1km² for each of the host rock types, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory), there is the possibility that surface disturbance could be less for the evaporite rock type, which could reduce any potential biodiversity effects.

At this stage, no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the biodiversity value of the site and its surrounds, the sensitivity of any habitats/species, and the level of habitat disturbance or loss.

7. Traffic and Transport

A. Higher Strength Rock

Assessment of Effects:

There would be an increase in transport movements throughout the operational phase, associated with the transport of construction material, excavated rock, radioactive waste, site staff, a range of heavy plant construction vehicles, concrete tankers and deliveries. The greatest number of transport movements generated during the operational phase is anticipated to be associated with the removal of excavated rock from the site and the transport of radioactive waste and backfill material to the site. The construction phase has been assessed as a discrete phase; however, in reality construction of the ILW/LLW vaults and HLW/SF disposal tunnels would take place concurrently with disposal throughout the operational phase. Therefore during the operational phase, there would also be transport movements associated with the removal of the excavated rock and the import of construction materials for the ILW/LLW vaults and HLW/SF disposal tunnels.

For the higher strength rock, it is estimated that the volume of higher strength rock excavated during construction would be approximately 5,225,000m³ for the Derived Inventory Reference Case excluding Pu/U and 13,800,000m³ for the Derived Inventory Upper Inventory. In the case of the Derived Inventory Reference Case excluding Pu/U, all of the excavated rock would be utilised on site (taking account of the volumes of excavated rock to be stored in surface bunds and used for backfilling of the HLW/SF disposal tunnels, the drift and shafts, and the common services area). No excavated rock would therefore need to be transported off-site. For the Derived Inventory Upper Inventory, an estimated 6,640,921m³ of surplus excavated rock would need to be taken off-site. However, it is assumed that all of the excavated rock would be transported off-site by rail, which would otherwise generate a significant number of transport movements by road, and therefore no significant effects on the road network from the transport of excavated rock are anticipated.



7. Traffic and Transport

A. Higher Strength Rock (cont)

The delivery of construction materials to the site would generate a significant number of transport movements. The import of construction materials for the higher strength rock ILW/LLW vaults and HLW/SF disposal tunnels could require an estimated 50,200 HGVs for the Derived Inventory Reference Case excluding Pu/U and an estimated 127,000 HGVs for the Derived Inventory Upper Inventory in total.

Buffer/backfill materials for the higher strength rock type would comprise crushed rock, NRVB and bentonite. The use of excavated rock from the construction of the underground facilities for backfilling of the HLW/SF disposal tunnels would significantly reduce the amount of backfill material that needs to be transported to site. However, NRVB and bentonite would need to be imported for buffering/backfilling. Approximately 1,000,000m³ of NRVB is expected to be required for the Derived Inventory Reference Case excluding Pu/U, increasing to 2,300,000m³ of NRVB for the Derived Inventory Upper Inventory. To backfill the HLW/SF disposal tunnels, approximately 510,000m³ of bentonite would need to be imported for the Derived Inventory Reference Case excluding Pu/U and 1,290,000m³ of bentonite for the Derived Inventory Upper Inventory. The import of this material is estimated to require approximately 75,300 HGVs in total for the Derived Inventory Reference Case excluding Pu/U and 186,400 HGVs for the Derived Inventory Upper Inventory respectively. It is noted that bentonite is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential effect.

Waste disposal is anticipated to take place from 2040 (when the first ILW/LLW waste packages would arrive). Two transport scenarios have been considered for the transport of radioactive wastes; rail (the Road/Rail scenario), and sea (the Sea/Road/Rail scenario). The potential effect of transporting radioactive waste predominantly by rail (assuming a 70:30 rail and road split) could be greater than predominantly by sea (assuming a 80:10:10 sea, rail and road split), as more transport movements by road would be required.

Environmental effects that could be considered as potentially significant on the road network include severance to pedestrians/cyclists induced by the flow of vehicles along a road, driver delay, loss of pedestrian/cyclist amenity, and accidents and safety as a result of an increase in traffic on the highway network.

It is assumed that the potential effects of the Derived Inventory Upper Inventory would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in the volume of excavated rock to be removed off-site, increase in the volume of backfill material required, and increase in the volume of radioactive waste, resulting in a greater number of transport movements.

Assumptions and uncertainties: It is assumed that construction materials, machinery and any construction waste (with the exception of excavated rock), and all backfill material would be transported to and from the site via road. It is also assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the site and may pass close to sensitive receptors such as residential areas. The assumptions made for transport by road are as follows: 10% of construction materials would be transported using a >3.5-7.5t HGV; 50% using a >7.5-17t HGV; and 40% using a >17t HGV; and 20% of backfill material would be transported using a >7.5-17t HGV, and 80% using a >17t HGV. All surplus excavated rock from the construction of the underground facilities is assumed to be transported off-site by rail.

For the transport of radioactive wastes, two transport scenarios have been considered; rail (the Road/Rail scenario), and sea (the Sea/Road/Rail scenario). For the Road/Rail scenario, it is assumed that 70% of the radioactive waste would be transported to the site by rail, with the remaining 30% transported by road. For the Sea/Road/Rail scenario, it is assumed that 80% of the radioactive waste would be transported to the site via ship, with the remaining 10% by road and 10% by rail. It is also assumed that existing port facilities would be utilised (i.e. no new sea transport infrastructure development would be required).

At this stage it is difficult to ascertain the extent of the traffic and transport effects as limited information is available. The significance of the traffic and transport effects of the operational phase would be dependant on the location of the site, the extent of use of rail facilities, the sensitivity of the local highway network, the location of construction and backfill materials, the disposal/end use of surplus excavated rock removed off-site and the means of transporting radioactive waste to the site. This may affect the range of measures that are implemented to mitigate transport related effects. It should be noted that any effects on the road network would be significantly reduced where rail or sea is used as the sole or primary means of transport.

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 7A of the construction phase assessment.

Summary of information requirements: No further information in addition to that identified for the construction phase has been identified (refer to the construction phase assessment for 7A. Higher Strength Rock).



7. Traffic and Transport

B. Lower Strength Sedimentary Rock

The potential traffic and transport effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 7A. Higher Strength Rock).

However, the scale of the effects would differ when compared to the higher strength rock type. As noted in the construction phase assessment, for the lower strength sedimentary rock type it is estimated that the volume of rock excavated during construction would be approximately 4,820,000m³ for the Derived Inventory Reference Case excluding Pu/U and 11,775,000m³ for the Derived Inventory Upper Inventory. In the case of lower strength sedimentary rock, a proportion of excavated rock would be used to construct surface bunds and the remainder of the excavated rock would be taken off-site. However, as per the higher strength rock type, it is assumed that all of the excavated rock would be transported off-site by rail.

In the case of the lower strength sedimentary rock type, the import of construction materials for the lower strength sedimentary rock ILW/LLW vaults and HLW/SF disposal tunnels could require an estimated 32,200 HGVs for the Derived Inventory Reference Case excluding Pu/U and an estimated 77,400 HGVs for the Derived Inventory Upper Inventory respectively.

Buffer/backfill materials for the lower strength sedimentary rock type would comprise bentonite and NRVB. The lower strength sedimentary rock excavated from the construction of the underground facilities would not meet backfill requirements and consequently none of the excavated rock retained on site would be used for backfilling. Therefore, for the lower strength sedimentary rock type all backfill material would need to be imported to the site.

It is estimated that to dispose of the Derived Inventory Reference Case excluding Pu/U ILW/LLW, approximately 1,050,000m³ of NRVB would be required. For the Derived Inventory Upper Inventory, the quantity of NRVB required would increase to approximately 2,540,000m³. To dispose of the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory HLW/SF approximately 257,000m³ and 731,000m³ of bentonite would be required respectively. The import of this material is estimated to require 46,100 HGVs in total for the Derived Inventory Reference Case excluding Pu/U and 111,500 HGVs in total for the Derived Inventory Upper Inventory respectively. Similar to the higher strength rock type, it is noted that bentonite is not widely available in the UK and therefore bentonite may need to be shipped from abroad, which would increase any potential effect.

C. Evaporite Rock

The potential traffic and transport effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 7A. Higher Strength Rock).

However, the scale of the effects would differ when compared to the higher strength rock type. As noted in the construction phase assessment, for the evaporite type it is estimated that the volume of rock excavated during construction would be approximately 4,273,000m³ for the Derived Inventory Reference Case excluding Pu/U and 11,366,000m³ for the Derived Inventory Upper Inventory. In the case of evaporite rock, a proportion of excavated rock would be retained on site for crushed rock backfilling, with the remainder of the excavated rock taken off-site. However, as per the higher strength rock type, it is assumed that all of the excavated rock would be transported off-site by rail.

In the case of the evaporite rock type, the import of construction materials for the evaporite rock ILW/LLW vaults and HLW/SF disposal tunnels could require an estimated 25,200 HGVs for the Derived Inventory Reference Case excluding Pu/U and an estimated 65,700 HGVs for the Derived Inventory Upper Inventory in total respectively.

Buffer/backfill materials for the evaporite rock type would comprise crushed rock salt and MgO. The use of excavated rock from the construction of the underground facilities for the backfilling of the HLW/SF disposal tunnels would significantly reduce the amount of backfill material that needs to be transported to site. However, approximately 144,000m³ of MgO would be required for buffering of the ILW/LLW vaults for the Derived Inventory Reference Case excluding Pu/U, increasing to 356,000m³ of MgO for the Derived Inventory Upper Inventory. The import of this buffer material is estimated to require approximately 6,300 HGVs in total for the Derived Inventory Reference Case excluding Pu/U and 15,600 HGVs in total for the Derived Inventory Upper Inventory respectively.

Headline Issues

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- Increase in traffic movements on the local road network throughout the operation phase, with potential severance, driver delay, pedestrian/cyclist amenity, and safety implications.



7. Traffic and Transport

Headline Issues (cont)

For all host rock types, the potential traffic and transport effect of the Derived Inventory Upper Inventory would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in the volume of construction materials required and construction waste generated, an increase in the volume of excavated rock to be transported off-site, an increase in the volume of buffer/backfill material required, and increase in the volume of radioactive waste, resulting in a greater number of transport movements.

As noted in the construction phase assessment, for both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory the evaporite rock type is estimated to generate the largest volume of excavated rock requiring removal off-site when compared to the other host rock types. For the higher strength rock Derived Inventory Reference Case excluding Pu/U, as all of the excavated rock would be retained on site, no transport of excavated rock from the construction of the underground facilities would be required. In the case of all of the host rock types, it is proposed that surplus excavated rock would be transported off-site via rail and therefore no significant effects on the road network from the transport of excavated rock are anticipated.

For both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory, it is estimated that the higher strength rock type could require the greatest number of HGVs for the import of buffer/backfill materials (taking account of the volumes of materials required for the ILW/LLW vaults and HLW/SF disposal tunnels), when compared to the other host rock types. The evaporite rock type is estimated to require the least number of HGVs for the import of buffer/backfill material when compared to the other host rock types, as only MgO sacks would need to be imported to the site.

For the higher strength rock Derived Inventory Reference Case excluding Pu/U it is estimated that 75,300 HGVs could be required for the import of buffer/backfill material, compared to 46,100 HGVs for the lower strength sedimentary rock type and 6,300 HGVs for the evaporite rock type. Similarly, for the higher strength rock Derived Inventory Upper Inventory, an estimated 186,400 HGVs could be required for the import of buffer/backfill material for the higher strength rock type, compared to 111,500 HGVs for the lower strength sedimentary rock type and 15,600 HGVs for the evaporite rock type.

For the higher strength rock and lower strength sedimentary rock types it is noted that bentonite would need to be imported for the backfilling of the HLW/SF disposal tunnels. Bentonite is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport impact.

For all host rock types, two transport scenarios have been considered for the transport of radioactive wastes; rail (the Road/Rail scenario), and sea (the Sea/Road/Rail scenario). The potential effect of transporting radioactive waste predominantly by rail (assuming a 70:30 rail and road split) could be greater than if radioactive waste is transported predominantly by sea (assuming a 80:10:10 sea, rail and road split), as fewer transport movements by road would be required. There would probably not be any difference in potential effect associated with the transport of radioactive waste between the different host rock types, as all would be designed to accept the same volumes of radioactive wastes.

8. Air Quality

A. Higher Strength Rock

Assessment of Effects:

As noted in Sustainability Theme 7A, there would be a significant increase in traffic movements on the local road network throughout the operational phase. Exhaust emissions from traffic (e.g. from HGVs, personnel vehicles and deliveries) could lead to a decrease in local air quality, particularly from nitrogen oxides, nitrogen dioxide and particulates. The greatest potential effect on air quality during the operational phase could be associated with the transport of construction materials, buffer/backfill material (NRVB and bentonite for higher strength rock) and radioactive waste to the site.

In the case of the higher strength rock, the use of excavated rock retained on site for backfilling of the HLW/SF disposal tunnels would negate the need to transport any crushed rock backfill material to the site for this purpose (refer to Sustainability Theme 7A). However, it is noted that bentonite is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport related air quality impact associated with the import of backfill material.



8. Air Quality

A. Higher Strength Rock (cont)

Exhaust emissions from plant and diesel engine emissions from diesel generators used to supply non mains power, may contribute to increases in particulate matter and gaseous pollutants (particularly nitrogen dioxide and carbon dioxide (CO₂)).

Once a GDF becomes operational, activities associated with the construction of the underground accesses (drift and shafts) and the first vaults would have been completed and therefore no further air quality effects associated with these works are anticipated. However, construction of the ILW/LLW vaults and HLW/SF disposal tunnels is anticipated to take place concurrently with disposal throughout the operational phase. Dust generated from waste disposal area construction and backfill activities, particularly storage and use of materials on site and excavations could have an effect on local air quality if unmanaged. The facility would comprise a ventilation system to remove flammable gases, fumes or dust generated by underground activities. Throughout operation there would be on-site emissions of dust and fumes/gases via the venting stacks which could negatively affect local air quality.

The potential effect of the Derived Inventory Upper Inventory could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an increase in the volume of construction materials required, an increase in surplus excavated rock to be transported off-site, an increase in the volume of backfill material required, and increase in the volume of radioactive waste to be disposed of, resulting in a greater number of transport movements. No transport of excavated rock off-site would be required for the Derived Inventory Reference Case excluding Pu/U, as all excavated rock could be utilised on site.

The transport of radioactive waste predominantly by rail (the Road/Rail scenario, which assumes a 70:30 rail and road split) could have a greater impact upon air quality when compared to transporting radioactive waste predominantly by sea (the Sea/Road/Rail scenario, which assumes a 80:10:10 sea, road and rail split), as a greater number of transport movements would be by road. As noted in the climate change assessment (refer to Sustainability Theme 9), CO₂ emissions for the Road/Rail scenario are estimated to be greater than those for the Sea/Road/Rail scenario.

Assumptions and uncertainties: Refer to Sustainability Theme 7A for traffic and transport assumptions. As a site has not been selected at this stage, the extent of any air quality effects associated with the operational phase is uncertain. The magnitude and significance of effects of emissions to air would depend on the location of the site and the sensitivity of the local environment, the extent of use of rail facilities, the proposed traffic routing and journeys, the location of construction materials, the end use of excavated rock removed off-site and the means of transporting radioactive waste to the site. Notwithstanding this, all equipment would comply with UK Government emissions regulations and would be sited to minimise effects on nearby sensitive receptors.

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 8A of the construction phase assessment.

Summary of information requirements: Further information on the levels of specific pollutants emitted from the ventilation systems and the effect that these may have on baseline air quality (e.g. Air Quality Management Areas) is required.

B. Lower Strength Sedimentary Rock

The potential air quality effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 8A. Higher Strength Rock).

However, the scale of any effects could differ when compared to the other host rock types. Similar to higher strength rock, for the lower strength sedimentary rock type the greatest potential effects on air quality during the operational phase could be associated with the transport of construction materials and buffer/backfill material (NRVB and bentonite in the case of lower strength sedimentary rock) to the site. In the case of the lower strength sedimentary rock type, excavated rock from the construction of the underground facilities would not be suitable for backfilling and therefore all backfill material would need to be imported. Similar to the higher strength rock type, it is noted that bentonite is not widely available in the UK and therefore bentonite may need to be shipped from abroad, which would increase any potential transport related air quality impact. However, taking account of estimated volumes, fewer HGVs could be required for the import of buffer/backfill materials when compared to the higher strength rock (refer to Sustainability Theme 7B).



8. Air Quality

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for the higher strength rock (refer to 8A. Higher Strength Rock).

However, the scale of any effects could differ when compared to the other host rock types. Similar to higher strength rock, for the evaporite rock type the greatest potential effects on air quality during the operational phase could be associated with the transport of construction materials and buffer material (MgO sacks in the case of the evaporite rock) to the site. Similarly, in the case of the evaporite rock type, the use of excavated rock retained on site for backfilling of the HLW/SF disposal tunnels would negate the need to transport any crushed rock to the site for this purpose. Taking account of estimated volumes, for the evaporite rock type fewer HGVs could be required for the import of buffer/backfill materials when compared to the higher strength rock (refer to Sustainability Theme 7C).

Headline Issues

- Potential for exhaust emissions from traffic to negatively affect local air quality, particularly transport associated with the import of construction materials and the import of buffer/backfill material to the site, which are likely to generate the greatest number of road transport movements.
- Potential for dust generated during operational activities to negatively affect local air quality if unmanaged.
- Potential for exhaust emissions from plant and diesel engine emissions from diesel generators to result in an increase in particulate matter and gaseous pollutants (nitrogen dioxide and carbon dioxide).
- Potential for on-site emissions of dust and fumes/gases from the venting stacks to negatively affect local air quality.

For all host rock types, the potential effect of the Derived Inventory Upper Inventory could be potentially greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in the volume of construction materials required and waste generated, surplus excavated rock to be removed off-site, backfill material required, and volume of radioactive waste to be disposed of, resulting in a greater number of transport movements.

As noted in Sustainability Theme 7, taking account of the estimated transport movements for the import of buffer/backfill materials to the site, a greater number of HGVs could be required for the higher strength rock (both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory) when compared to the other host rock types. Therefore the transport related air quality effect of the higher strength rock type associated with the import of construction materials and buffer/backfill material could be greater. For the higher strength rock and lower strength sedimentary rock types it is also noted that bentonite would need to be imported for the backfilling of the HLW/SF disposal tunnels. Bentonite is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport related air quality impact.

9. Climate Change

A. Higher Strength Rock

Assessment of Effects:

The emission of CO₂ (due to the direct or indirect combustion of fossil fuel) from traffic and plant, any use of diesel generators to power drilling rigs and associated plant for the construction of the ILW/LLW vaults and HLW/SF disposal tunnels, the embodied energy in construction materials used, and the on-site emissions of dust and fumes/gases via the venting stacks would contribute to climate change. When considering the source of the construction material used, the distance and method of transportation would have a direct effect on overall carbon emissions (e.g. the different emissions associated with transport by road, rail or ship).

The transport of buffer/backfill material for the higher strength rock Derived Inventory Reference Case excluding Pu/U is estimated to generate in the region of 39,000 tonnes of CO₂, increasing to 96,600 tonnes of CO₂ for the import of backfill material for the Derived Inventory Upper Inventory. It should be noted that bentonite is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport related carbon emissions associated with the import of buffer/backfill material.



9. Climate Change

A. Higher Strength Rock (cont)

With respect to carbon emissions associated with the transport of radioactive waste, for the Road/Rail scenario assuming that 50% of radioactive wastes is transported by rail and the remaining 50% is transported by road, the transport of radioactive wastes is estimated to generate in the region of 53,400 tonnes of CO₂ for the Derived Inventory Reference Case excluding Pu/U and 104,800 tonnes of CO₂ for the Derived Inventory Upper Inventory. If radioactive wastes were to be transported primarily by sea (Sea/Road/Rail scenario), assuming that 80% of radioactive waste is transported by sea, with the remaining 10% by road and 10% by rail, the transport of radioactive wastes is estimated to generate in the region of 10,700 tonnes of CO₂ for the Derived Inventory Reference Case excluding Pu/U and 21,600 tonnes of CO₂ for the Derived Inventory Upper Inventory, significantly less than the Road/Rail scenario.

The surface facilities and infrastructure or the underground facilities would not be particularly vulnerable to the effects of climate change other than potential flooding from increased frequency and magnitude of storms if the site was located within an area at risk of flooding or surface water run-off was not managed appropriately. Given that the majority of the activities would be underground, changes in weather patterns as climate changes (e.g. very cold winters and hotter drier summers) are unlikely to significantly affect operational activities.

There is the potential for climate change to affect the transport of radioactive waste by sea, for example an increase in storm surges and increase in the frequency and magnitude of storms could disrupt transport operations, restricting operating periods.

Assumptions and uncertainties: Refer to Sustainability Theme 7 for traffic and transport assumptions. The surface site area and the scale of surface development is assumed to be the same for the different waste inventories. At this stage no site has been selected and therefore the location of the site in relation to floodplains or flood sensitive areas is unknown.

It is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that for the Derived Inventory Upper Inventory and therefore there would probably not be a significant difference in potential climate change effects between the different waste inventories.

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for construction should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 9A of the construction phase assessment.

Summary of information requirements: No further information in addition to that identified for the construction phase has been identified (refer to the construction phase assessment for 9A. Higher Strength Rock). However, the baseline situation should be reviewed to determine any change.

B. Lower Strength Sedimentary Rock

The potential effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 9A. higher Strength Rock). However, the scale of any effects would differ when compared to the higher strength rock type. The transport of buffer/backfill material for the lower strength sedimentary rock Derived Inventory Reference Case excluding Pu/U is estimated to generate in the region of 33,200 tonnes of CO₂, increasing to 84,400 tonnes of CO₂ for the import of backfill material for the Derived Inventory Upper Inventory. Similar to the higher strength rock type, it is noted that bentonite is not widely available in the UK and therefore bentonite may need to be shipped from abroad, which would increase any potential transport related carbon emissions.

Carbon emissions associated with the transport of radioactive waste would be the same as for the higher strength rock type, as a GDF within lower strength sedimentary rock would be designed to accept the same volumes of radioactive waste.

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 9A. Higher Strength Rock). However, the scale of any effects would differ when compared to the higher strength rock type. The transport of buffer material for the evaporite rock Derived Inventory Reference Case excluding Pu/U is estimated to generate in the region of 23,100 tonnes of CO₂, increasing to 65,400 tonnes of CO₂ for the import of buffer material for the Derived Inventory Upper Inventory.

Carbon emissions associated with the transport of radioactive waste would be the same as for the higher strength rock type, as a GDF within evaporite rock would be designed to accept the same volumes of radioactive waste.



9. Climate Change

Headline Issues

- Increase in carbon dioxide emissions during operation associated with vehicle movements, any use of diesel generators to power plant, and the energy used in facilities and infrastructure (including the embodied energy within construction and backfill materials).

For all host rock types, the potential effect of the Derived Inventory Upper Inventory could be potentially greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with an associated increase in construction materials required and construction wastes, an increase in the volume of surplus excavated rock to be removed off-site, an increase in the volume of backfill material required, and increase in the volume of radioactive waste to be disposed of.

Carbon emissions and the quantities of embodied carbon are expected to vary between the different host rock types. For both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory, the higher strength rock type is estimated to generate the greatest amount of carbon emissions associated with the transport of buffer/backfill material for the ILW/LLW vaults and HLW/SF disposal tunnels when compared to the other host rock types.

For the Derived Inventory Reference Case excluding Pu/U the transport of buffer/backfill material for the ILW/LLW vaults and HLW/SF disposal tunnels is estimated to generate approximately 39,000 tonnes of CO₂ for the higher strength rock type, compared to 33,200 tonnes of CO₂ for the lower strength sedimentary rock, and 23,100 tonnes of CO₂ for the evaporite rock. Similarly, for the Derived Inventory Upper Inventory, the transport of buffer/backfill material for the ILW/LLW vaults and HLW/SF disposal tunnels for the higher strength rock type is estimated to generate approximately 96,600 tonnes of CO₂, compared to 84,400 tonnes of CO₂ for the lower strength sedimentary rock type, and 65,400 tonnes of CO₂ for the evaporite rock type.

For the higher strength rock and lower strength sedimentary rock types it is noted that bentonite would need to be imported for the backfilling of the HLW/SF disposal tunnels. Bentonite is not widely available in the UK and therefore bentonite may need to be shipped from abroad, which would increase any potential transport related carbon emissions.

Carbon emissions associated with the transport of radioactive waste would be the same for each of the host rock types, as they would be designed to accept the same volumes of radioactive waste.

Overall for the construction and operational phase, (taking account of the CO₂ emissions estimates for the transport of surplus excavated rock off-site, for the transport of ILW/LLW vault, HLW/SF disposal tunnel, underground accesses (drift and/or shafts) and common service area construction materials, and ILW/LLW vault and HLW/SF buffer/backfill material), for the Derived Inventory Reference Case the evaporite rock type would probably generate the greatest amount of transport related CO₂ emissions, as although fewer construction and buffer/backfill materials would be required when compared to the other host rock types, a significantly greater volume of surplus excavated rock would need to be removed off-site. Total CO₂ emissions for the evaporite rock type Derived Inventory Reference Case are estimated to be 157,600 tonnes of CO₂, compared to 98,800 tonnes of CO₂ for lower strength sedimentary rock and 66,800 tonnes of CO₂ for higher strength rock.

For the Derived Inventory Upper Inventory the lower strength sedimentary rock type would probably generate the greatest amount of transport related CO₂ emissions, due to the volume of surplus excavated rock to be removed off-site and the volume of construction materials and buffer/backfill materials to be transported to the site. Total CO₂ emissions for the lower strength sedimentary rock type Derived Inventory Upper Inventory are estimated to be 436,700 tonnes of CO₂, compared to 426,300 tonnes of CO₂ for evaporite rock and 412,500 tonnes of CO₂ for higher strength rock.



10. Noise and Vibration

A. Higher Strength Rock

Assessment of Effects:

Operational activities associated with a GDF are likely to result in perceptible increases in noise. Significant sources of on-site noise include drilling and blasting of the disposal tunnels, earth moving equipment, rock crushing facilities, rail traffic and road traffic (HGVs, concrete trucks, forklift trucks, delivery vehicles, vans and personnel vehicles) and operations within surface facilities. The construction of the ILW/LLW vaults and HLW/SF disposal tunnels by means of drilling and blasting, and the movement and crushing of excavated rock in particular would be a perceptible source of noise, both continuous background noise and intermittent noise. However, drilling and blasting works would be undertaken at depth, which would help to mitigate any noise disturbance on the surface.

Noise disturbance may also arise from sustained high levels of traffic associated with the transport of construction materials and construction wastes, excavated rock, backfill material, radioactive wastes for disposal, and personnel to and from the site (refer to Sustainability Theme 7A).

Assuming that traffic would have to use local roads (e.g. lower order, B and C roads) and may pass close to sensitive receptors, it is anticipated that there may be a negative noise effect from traffic, particularly HGVs, passing along non-primary routes. However, the exact route(s) would depend on the site(s) location and extent of local receptors.

Activities such as drilling and blasting and HGV and plant movements, may also have vibration effects. Vibration effects from drilling and blasting would be difficult to quantify until such time as the ground conditions at the site are known, as the nature of the rock at the site needs to be confirmed to determine the level of propagation from the source, ideally through a test blast.

Depending on the proximity of sensitive receptors to the site, there is the potential for noise and vibration to have an effect on sensitive receptors (occupants of residential buildings, community and recreational facilities, noise sensitive businesses and enterprises etc). However, whilst activities on site would generate noise and vibration, any effects from on-site noise would probably not be significant due to the need to adhere to the requirements of legislation (Control of Pollution Act, 1974) and best practice set out in BS 5228: 2009 (Code of Practice for Noise and Vibration Control on Construction and Open Sites). Good management of any works would ensure that a breach of limits would be unlikely. However, there would be the potential for HGV movements along the local road network to cause a noise nuisance.

There would probably not be any difference in noise and vibration effects between the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory, due to the need to adhere to the requirements of legislation.

Assumptions and uncertainties: The scale of surface development is assumed to be the same for the different waste inventories.

It is assumed that all construction materials, machinery and construction waste (with the exception of excavated rock) would be transported to and from the site via road. It is also assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the site and may pass close to sensitive receptors such as residential areas. All of the surplus rock excavated from the construction of the underground facilities is assumed to be transported off-site via rail. Two transport types have been considered for the transport of radioactive wastes; rail and sea. For the rail type, it is assumed that 70% of the radioactive waste would be transported to the site by rail, with the remaining 30% transported by road. For the sea type, it is assumed that 80% of radioactive waste would be transported to the site via ship, with the remaining 10% by road and 10% by rail. It is also assumed that existing port facilities would be utilised (i.e. no new sea transport infrastructure development would be required).

At this stage no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the site and works to sensitive receptors and the level and extent of noise and vibrations generated.

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 10A of the construction phase assessment.

Summary of information requirements: Further information on the proposed operational activities, including information on working hours, the likely areas of working and the noise levels of equipment to be used, is required to enable a more detailed and accurate assessment of the effects to be made.

10. Noise and Vibration



B. Lower Strength Sedimentary Rock

The potential noise and vibration effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 10A. Higher Strength Rock).

In the case of the lower strength sedimentary rock type, the underground facility would be excavated by a combination of tunnel boring machine, road header and drill and blast methods. Noise levels of the different construction techniques vary, with drill and blast methods generating both continuous background noise from drilling, and intermittent high frequency noise from the detonation of explosives. In comparison, tunnel boring machines and road header machines are likely to be a source of continuous background noise at a lower frequency. However, due to the need to adhere to the requirements of legislation there would probably not be any significant difference in effects.

C. Evaporite Rock

The potential noise and vibration effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 10A. Higher Strength Rock).

In the case of the evaporite rock type, the underground facility would be excavated by continuous miner and/or road header machines. Continuous miners and road headers are likely to be a source of continuous background noise at a lower frequency. However, due to the need to adhere to the requirements of legislation there would probably not be any significant difference in effects.

Headline Issues

- Potential for noise disturbance and/or vibration effects from surface operation activities (e.g. from earth moving equipment, rail transport, HGVs, concrete trucks, forklift trucks, delivery vehicles, vans, personnel vehicles, cranes and belt conveyors and rock crushing facilities).
- Potential for noise disturbance and vibration effects from underground excavation works (both continuous background noise on a 24hr basis and/or intermittent noise during blasting).

For all of the host rock types, there would probably not be any difference in noise and vibration effects between the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory, due to the need to adhere to the requirements of legislation.

As noted in the construction phase assessment, for the higher strength rock type, it is proposed to excavate the underground facility using drill and blast methods. For the lower strength sedimentary rock type the underground facility would be excavated by a combination of tunnel boring machine, road header and drill and blast methods, and in the case of the evaporite rock type, the underground facility would be excavated by continuous miner and/or road header machines.

? As noted in the assessment, the noise levels of the different construction techniques vary, with drill and blast methods generating both continuous background noise from drilling, and intermittent high frequency noise from the detonation of explosives. In comparison, tunnel boring machines, road header machines and continuous miners are likely to be a source of continuous background noise at a lower frequency. However, the use of different techniques would be unlikely to result in any significant difference in effects, as specified noise limits for the works would need to be adhered to.

The type of host rock is likely to affect the extent to which vibrations penetrate and affect an area due to the rock type's amplification or damping properties. Differences in vibration effects would be difficult to quantify until such time as the ground conditions at the site are known, as the nature of the rock at the site needs to be confirmed to determine the level of propagation from the source.

At this stage, no site has been selected and subsequently the predicted effect is uncertain. The potential for effects would depend on the proximity of the site and works to sensitive receptors and the level and extent of noise and vibrations generated.

11. Land Use

A. Higher Strength Rock



Assessment of Effects:

As noted in the construction phase assessment for the higher strength rock type, an approximate site area of 1.1km² would be required for both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory. Within this surface site area would be the surface facilities and infrastructure (construction support, operational management and administration, workshops and transport related infrastructure), along with 3,589,000m³ of rock excavated during the construction of the underground facilities stored as surface bunds.

As per the construction phase, the site would remain fenced off and inaccessible to the public throughout the operational phase for health and safety reasons. If a greenfield location is selected, there would be the potential for the land take to result in a change in existing land use patterns and/or to result in the loss or severance of agricultural or community/recreational land. The significance of the land take, particularly loss of agricultural or community/recreational land would depend on the quality of the land and the characteristics of the area surrounding the site (i.e. the extent of land of equal value in the surrounding area).

Assuming that all operation activities would take place within the surface site area, no further land take in addition to that for the construction phase is anticipated at the operational phase. Should surface operational activities extend outside of the surface site area for the construction phase there may be the potential for effects in addition to those identified for the construction phase.

No significant effects are anticipated from the transport of radioactive waste by sea, assuming that existing ports are utilised. However, should new port infrastructure be required for the transport of radioactive waste by sea, the land use effect of this would need to be assessed.

Assumptions and uncertainties: It is assumed for the purposes of this assessment that the site would be greenfield. As such, depending on the grade of the agricultural land, it is assumed that good quality agricultural land (grades 1-3a) could be affected by the development.

The surface site area is assumed to be the same for the different waste inventories, as the maximum rate of waste package delivery would not increase. It is assumed for the purposes of this assessment the entire area of surface land take would remain fenced off and inaccessible to the public throughout the operational phase, and that no further land take in addition to that for the construction phase would be required. If radioactive wastes were transported predominately by sea, it is assumed that existing port facilities would be utilised (i.e. no new sea transport infrastructure development would be required).

It is assumed that the surface site area for the Derived Inventory Reference Case excluding Pu/U would be the same as that for the Derived Inventory Upper Inventory and therefore there would probably not be any significant difference in potential effects on land uses between the different waste inventories.

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 11A of the construction phase assessment.

Summary of information requirements: No further information in addition to that identified for the construction phase has been identified (refer to the construction phase assessment for 11A. Higher Strength Rock). Consideration needs to be given to the effect of operational activities on surrounding land uses.

B. Lower Strength Sedimentary Rock

The potential land use effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 11A. Higher Strength Rock). No effects in addition to those identified for higher strength rock are anticipated.

Similar to the higher strength rock type, the surface site area for the lower strength sedimentary rock type would be approximately 1.1km². The surface site area would include surface facilities and infrastructure and up to 3,589,000m³ of excavated rock in bunds (for both the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory).

11. Land Use

C. Evaporite Rock

The potential land use effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the



same as those identified for higher strength rock (refer to 11A. Higher Strength Rock).

Similar to the higher strength rock type, the surface site area for the evaporite rock type would be approximately 1.1km², assuming that the surface site area includes surface facilities and infrastructure and surface screening bunds. In the case of the evaporite rock type none of the excavated rock would be stored in surface bunds within the site, as the excavated rock salt would not be suitable for this. Instead the only excavated rock to be retained on site would be that required for backfilling of the HLW/SF disposal tunnels, shafts and common services area (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory), which would be stored within a suitably designed area. Surface screening bunds would be created using spoil and imported material as required. Given that a smaller volume of excavated rock would be stored on site for the evaporite rock type when compared to the other host rock types (which propose 3,589,000m³ in bunds on the site), there is the possibility that land take could be less.

Headline Issues

- Potential for a GDF to have an effect on existing land uses, particularly where land take results in the loss or severance of agricultural land or community/recreational land.
- There would probably not be any significant difference in potential land use effects between the different waste inventories and different host rock types, as the surface site area is assumed to be the same (approximately 1.1km² for each of the host rock types). Notwithstanding this, given that a smaller volume of excavated rock would be stored on site for the evaporite rock type (estimated to be 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory) when compared to the other host rock types (estimated to be 3,589,000m³ in bunds on the site for both waste inventories), there is the possibility that land take could be less for the evaporite rock type.

12. Socio-economics

A. Higher Strength Rock

Assessment of Effects:

Once a GDF is operational, activities associated with the construction of the surface facilities and infrastructure, drift, shafts and the first vaults would have been completed. Key activities taking place during the operational phase of a GDF are the delivery, transfer and emplacement of radioactive waste, the ongoing excavation of disposal tunnels (which would take place concurrently with disposal throughout the operational phase) and backfilling of the waste.

Similar to the construction phase, operation of a GDF would involve the employment of a range of specialist contractors (e.g. site management, civil, mining and electrical engineers, geologists and safety advisors). A proportion of jobs, particularly support jobs (e.g. plant operators, crane drivers and security staff) may be immediately suitable for the local workforce, creating opportunities for the employment of local contractors and individuals.

As noted in the construction phase assessment, health and safety regulations on the number of people working are a key determinant of the size of the workforce that can be effectively deployed. Ancillary activities, rock crushing, transport of spoil and the transport of radioactive waste for disposal, would as far as possible be sized to handle a steady stream of material. The operation of a GDF would therefore provide regular employment for activities which can be cost effectively performed by a local workforce.

The NDA estimate that, on average 623 people per year could be employed during the operational phase (including manpower for further construction), for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory.

Taking account of these aspects and the scale and duration of the operational phase, the effects on local employment would be beneficial, especially as initial costs, for example training, are a small proportion of the overall operational expenditure. However, there would be a reduction in employment from the construction phase.

12. Socio-economics

A. Higher Strength Rock (cont)

A GDF would be a major user and producer of materials and would occupy a significant position within the supply chains of other industries. It would have the potential to affect local prices, for example for cement or aggregates, due to activities resulting directly from construction, but also



in local markets used by the workforce.

A GDF has a number of aspects with socio-economic consequences, amongst these are:

Particular requirements for cutting, drilling and crushing equipment;

Offsetting decreases in technologies such as stabilisation techniques and/or pumping; and

Energy requirements.

The main effects relate to supply chains and are:

Rock specific upstream supply chains (possibly dependant on which part of the world has the best practice for similar operations in that rock type and/or experience in supply of specialist equipment;

Rock specific downstream supply chains (e.g. road aggregates, coastal defences and building materials); and

Potential use of own-supply to avoid hold up and local monopoly issues.

There may be further effects relating to the existing socio-economic structure. Higher strength rock types may be generically associated with a particular form of economy that has developed to date on the surface, for example distributed farming communities, with features such as low capacity and extended transport networks with corresponding effects on site access and ease of access for employees.

The rock type may provide opportunities for synergy and corresponding economic efficiency benefits. For example, it may meet requirements as a building material which is a sensitive response to local landscape conditions. However, such uses and effects on the supply chain would depend on demand and supply at the time of arising.

Site based staff and visiting contractors would introduce a demand for local accommodation and services. Given the duration of operation, there would be the potential that site based staff may relocate and become resident in an area for the duration of the works and, in addition to spending their money in the local economy, may bring families with children who may increase the demand for school places etc. Visiting staff would require accommodation in local hotels with requirements for different local services, for example taxis and restaurants.

It should be noted that a local community in a greenfield/rural setting may be particularly sensitive to the demand created by such activities with potentially both significant positive and negative effects.

There would also be the potential for a GDF to have a negative effect on the desirability of the surrounding area as a place to live, work and visit. Knock-on effects from a GDF could include a decrease in land value and house prices in the local area due to the presence of the facility, which may be viewed as unfavourable. Operational activities could potentially have a negative effect on the viability of businesses in close proximity (e.g. effects on productivity due to disturbance to staff from noisy activities).

Depending on the location and the proximity of local populations, there may be a negative effect on quality of life from construction and operational activities (e.g. associated with the increase in traffic on the road network, noise, vibration and air quality effects from construction works and traffic), although it is deemed to be uncertain until the location of a GDF is identified. Potential receptors include neighbouring residents, schools and users of community, leisure and recreational facilities, public open space and rights of way.

Overall, the potential effect of the Derived Inventory Upper Inventory in relation to socio-economic effects could potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility and associated increase in construction period. Compared to the Derived Inventory Reference Case excluding Pu/U, over the whole time period, the Derived Inventory Upper Inventory would:

Increase the case for dedicated investment in activities at the site but also in the service sector; and

Reduce the need for temporary accommodation and services.

12. Socio-economics

A. Higher Strength Rock (cont)

There is not, however, expected to be any increase in employment associated with the Derived Inventory Upper Inventory, as health and safety regulations govern the level of activity on site. The annual scale of works would therefore not increase; instead the operational period would be



longer.

Assumptions and uncertainties: The scale of surface development is assumed to be the same for the different waste inventories. It is assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the site and may pass close to sensitive receptors such as residential areas. It is assumed that the level of employment would be the same of the different waste inventories, as the scale of works would not increase on an annual basis, instead the operational period would be longer.

The potential socio-economic effects of a GDF are largely dependent on the proximity of local populations to the site, the relationship with the upstream and downstream supply chains, the nature of the local economy and the sensitivity to the character of the effects predicted. As such at this stage the majority of the socio-economic effects are uncertain.

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 12A of the construction phase assessment.

B. Lower Strength Sedimentary Rock

The potential socio-economic effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 12A. Higher Strength Rock).

However, as noted in the construction phase assessment, the scale of any effects could differ when compared to the higher strength rock type due to the host rock type and construction techniques. Due to its limited commercial value, any potential effects associated with the release of surplus excavated lower strength sedimentary rock to the market could be less when compared to the higher strength rock type. Although this is to some extent dependent on the level of demand and availability of supply at the time of arising.

There would also be a greater requirement for specialist equipment for the lower strength sedimentary rock type, including the use of tunnel boring and road header machines, along with drill and blast techniques for the construction of the underground facility.

C. Evaporite Rock

The potential socio-economic effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 12A. Higher Strength Rock).

However, as noted in the construction phase assessment the scale of any effects could differ when compared to the higher strength rock type due to the host rock type and construction techniques. The potential resource value of evaporite may result in the surplus excavated rock affecting the markets that use evaporites (e.g. road grit and cement production) by causing an oversupply of such product. This could have potentially negative effects on the existing suppliers of such products. There would also be a greater requirement for specialist equipment for the evaporite rock type when compared to the higher strength rock, including the use of continuous miner and/or road header machines for the construction of the underground facility.

Headline Issues

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- Potential for a proportion of jobs to be suitable for the local workforce, creating opportunities for the employment of local contractors and individuals.
 - Potential for site based staff and visiting contractors to introduce a demand for local accommodation and services.
- There would not be any significant difference in employment opportunity between the different waste inventories and different host rock types. Fewer construction staff would be required to operate tunnel boring machines, road headers and continuous miners in comparison to drill and blast. However, these would be specialist jobs and therefore would not have any significant effect on potential local employment opportunities.

12. Socio-economics

Headline Issues (cont)

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- Potential for a GDF, as a major user and producer of materials, to affect supply chains and local prices.
- Potential for a GDF to have a negative effect on the desirability of the surrounding area as a place to live, work and invest, with



potential for negative effects on local land values and house prices.

- Potential for GDF activities to have a negative effect on the quality of life of local populations (e.g. the increase in traffic on the road network, noise, vibration and air quality effects from operations and traffic).

For all of the host rock types, operational activities for the Derived Inventory Upper Inventory would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility. The potential effect of the Derived Inventory Upper Inventory could therefore be greater.

As noted in the construction phase assessment, there would be the potential for surplus excavated higher strength and evaporite rock released into the market to effects the markets, for example wholesale supply prices, particularly the markets that use evaporites (e.g. road grit and cement production). Due to its limited commercial value, any potential effects associated with the release of surplus excavated lower strength sedimentary rock to the market could be less when compared to the higher strength rock type. Although this would be to some extent dependent on the level of demand and availability of supply at the time of arising. There would also be the potential for the requirement of significant volumes of construction and backfill materials to affect the markets; however the potential effects cannot be ascertained at this stage.

There would be a greater requirement for specialist equipment for the lower strength sedimentary rock and evaporite rock types (i.e. tunnel boring machines, road headers and continuous miners) when compared to the higher strength rock type.

There would be the potential for operational activities to have a negative effect on the quality of life of local populations (e.g. associated with the increase in traffic on the road network, noise, vibration and air quality effects from construction works and traffic). There would also be the potential for a GDF to have a continued negative effect on the desirability of the surrounding area as a place to live, work and invest. Knock-on effects from a GDF could include a decrease in land value and house prices in the local area due to the presence of the facility, which may be viewed as unfavourable. Operational activities could potentially have a negative effect on the viability of businesses in close proximity (e.g. effects on productivity due to disturbance to staff from noisy activities).

At this stage no site has been selected and subsequently the potential for effects on quality of life, business productivity and desirability of the area is uncertain. The potential for effects would depend on the proximity of the site to sensitive receptors and the level and extent of any disturbance.

13. Health and well-being

A. Higher Strength Rock

Assessment of Effects:

Depending on the location of the site and the proximity of local populations, operational activities could have a negative effect on health and well-being (e.g. disturbance from noise and vibrations, and air quality effects from works and traffic). Potential receptors include on-site staff and visitors, neighbouring residents, schools and users of community, leisure and recreational facilities, open space and rights of way.

Depending on the type of higher strength rock, there may be a risk to human health from drilling and blasting activities associated with the release and chronic inhalation of silica dust from silicate rich rocks (e.g. granite), which depending on the extent of exposure to silica dusts can cause silicosis, an incurable lung disease. Without adequate dust controls, there would be the potential for workers to develop accelerated silicosis over a period of 5-10 years. Notwithstanding this, any potential risk to health can be prevented by following appropriate dust prevention and health and safety procedures.

A GDF may be subject to protest action from opposition groups and local communities, particularly when the facility opens and begins to receive waste. This may potentially increase the fear of crime through the fear of vandalism and an influx of a large number of people into a localised area. However, the extent of any opposition and its magnitude is unknown and would be dependent on the degree of antagonism by the local community, protestors and the security of a GDF.

13. Health and well-being

A. Higher Strength Rock (cont)

There potentially would be concerns regarding health and safety associated with the delivery, transfer and emplacement of radioactive waste at a GDF. There would be the potential for the perceived risks associated with a GDF to cause concern, which could affect people's health and well-being (e.g. increased/elevated stress levels). The consideration of radiological effects is outside the scope of this assessment. However, a GDF



and associated transport infrastructure would be designed to meet regulatory requirements with regard to the protection of the environment and public from radiological hazards. The level of protection would be consistent with the national standard at the time of disposal.

There may be some beneficial effects on well-being due to the continued implementation of a community benefits package.

Operational activities for the Derived Inventory Upper Inventory would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility. The potential effects of the Derived Inventory Upper Inventory on health and well-being could therefore be greater than that of the Derived Inventory Reference Case excluding Pu/U.

Assumptions and uncertainties: The scale of surface development is assumed to be the same for the different waste inventories. It is assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the sites and may pass close to sensitive receptors such as residential areas. At this stage no site has been selected and subsequently the potential effects on health and well-being are uncertain. The potential effects would depend on the proximity of the site and construction activities to sensitive receptors and the extent of any disturbance. At this stage it is uncertain to what extent there would be active opposition to a GDF.

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 13A of the construction phase assessment.

Summary of information requirements: Further information is required on the proximity of the site to sensitive receptors, and the proposed operational activities within the site, to identify the likely effects in more detail.

B. Lower Strength Sedimentary Rock

The potential health and well-being effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 13A. Higher Strength Rock). No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The potential health and well-being effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 13A. Higher Strength Rock). No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

- Potential for operational activities to have a negative effect on health and well-being.
- Potential for a GDF to be subject to protest action from opposition groups and local communities.
- Potential for perceived risks associated with a GDF to cause concern.

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For all of the host rock types, operational activities for the Derived Inventory Upper Inventory would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, and therefore the potential effect of the Derived Inventory Upper Inventory on health and well-being could be greater.

As noted in the assessment, chronic inhalation of silicate rich rock over a long time period can cause silicosis. There would be the potential for silicate to be present within all of the rock types; however the silica content of higher strength rock could potentially be greater. Notwithstanding this, due to the need to adhere to health and safety legislation, there would probably not be any significant difference in potential effects between the different host rock types. At this stage no site has been selected and subsequently the potential for effects are uncertain. The potential for effects would depend on the proximity of construction activities to sensitive receptors and the extent of any disturbance. At this stage it is uncertain to what extent there would be active opposition to a GDF

14. Safety

A. Higher Strength Rock

Assessment of Effects:

Once a GDF becomes operational, activities associated with the construction of the surface facilities and infrastructure, underground accesses



(drift and shafts) and the first vaults would have been completed, reducing construction works on site and any health and safety risk associated with these works. However, there would still be health and safety implications associated with the construction of the ILW/LLW vaults and HLW/SF disposal tunnels throughout the operational period, which would take place concurrently with disposal. Operational activities, particularly construction of the ILW/LLW vaults and HLW/SF disposal tunnels by means of drilling and blasting; the delivery, transfer and emplacement of radioactive waste; and backfilling of waste, would pose a number of significant hazards to the on-site workforce, visitors to the site, and potentially also to the public (i.e. local communities in the surrounding area).

Potential major hazards include: collision and impact hazards (e.g. involving plant, vehicles and personnel); explosion and detonation (e.g. associated with the use of explosives); exposure to substances hazardous to health (e.g. contact with cement, dusts etc); entrapment, asphyxiation, and loss of ventilation (e.g. associated with underground works); electrical hazards (e.g. electrical shock from live cables); and other occupational hazards such as working at height and manual handling.

However, although there would be many potential risks, any risk would have been identified and managed through the contractor(s)/operator(s) compliance with health and safety legislation and risk management procedures. As such, the potential effect would not be significant.

Operational activities would be unlikely to present a significant risk to the public (i.e. local communities) provided access to the site was restricted and the relevant health and safety procedures were in place. Although any increase in traffic movements could potentially increase the risk of road traffic accidents. A GDF and associated transport infrastructure would be designed to meet regulatory requirements with regard to the protection of the environment and public from radiological hazards. The level of protection would be consistent with the national standard at the time of waste disposal.

It is assumed that operational activities for the Derived Inventory Reference Case excluding Pu/U would be similar in scale to the Derived Inventory Upper Inventory, as health and safety regulations govern the level of activity on site and therefore the scale of the work would not increase, instead the period would be longer. Therefore there would probably not be a significant difference in potential safety effects between the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory. However, the length of time involved may increase the statistical chance of accidents occurring.

Assumptions and uncertainties: It is assumed that the staff undertaking the works would not be subjected to any higher degree of risk than if they undertook such activities elsewhere as they would be professionally trained and should understand the risks of the activities which they practice. A GDF would be licensed under the Nuclear Installations Act 1965, which infers a high degree of control in accordance with the nuclear site licence.

Proposed Mitigation/Enhancements: The mitigation measures and enhancements recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 14A of the construction phase assessment.

Summary of information requirements: Further information is required on the proximity of the site to sensitive receptors, and the proposed operational activities, to identify the likely effects in more detail. In particular, the exposure of sensitive receptors to hazards associated with normal activities as well as accident and emergency situations should be considered.

B. Lower Strength Sedimentary Rock

The potential safety effects that could occur for the lower strength sedimentary rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 14A. Higher Strength Rock). No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The potential safety effects that could occur for the evaporite rock type, and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 14A. Higher Strength Rock). No effects in addition to those identified for the higher strength rock type are anticipated for the evaporite rock type.

14. Safety

Headline Issues

-	- Risk to human health and safety from construction and operational activities.
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- Potential for an increased risk of road traffic accidents associated with any increase in traffic movements.

There would probably not be any significant differences in potential effects between the different waste inventories and different host rock types, as health and safety regulations govern the level of activity on site and therefore the scale of the operational activities are not expected to increase. However, the length of time involved may increase the statistical chance of accidents occurring.

15. Waste

A. Higher Strength Rock

Assessment of Effects:

Once a GDF is in operation, construction of the surface facilities and infrastructure, drift, shafts and the first vaults would have been completed, reducing construction works on site and any waste arisings associated with these works. However, the construction of the ILW/LLW vaults and HLW/SF disposal tunnels would be ongoing throughout the operational period, which would take place concurrently with radioactive disposal.

For the higher strength rock type, the most significant waste stream during the operational phase would be excavated rock from the construction of the ILW/LLW vaults and HLW/SF disposal tunnels. As noted in the construction phase assessment, the construction of a GDF would require large volumes of hard rock to be excavated; approximately 5,225,000m³ for the Derived Inventory Reference Case excluding Pu/U and 13,800,000m³ for the Derived Inventory Upper Inventory. For the higher strength rock type it is proposed that up to 3,589,000m³ of the excavated rock would be used to construct surface bunds around the site. In addition, 1,190,000m³ of excavated rock for the Derived Inventory Reference Case excluding Pu/U, and 3,010,000m³ of excavated rock for the Derived Inventory Upper Inventory, would be used as backfill material for backfilling the HLW/SF disposal tunnels (which would take place during the operational phase).

For both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory, a further 263,771m³ and 296,308m³ would be required for the backfilling of the drift and shafts, and common services area respectively (which would take place during the closure phase).

In the case of the Derived Inventory Reference Case excluding Pu/U, all of the higher strength rock excavated would be utilised on site. For the Derived Inventory Upper Inventory, not all of the excavated rock would be utilised on site. The surplus excavated rock, estimated to be approximately 6,640,921m³ for the Derived Inventory Upper Inventory, would be taken off-site. Notwithstanding this, the potential exists for the beneficial use of the waste excavated rock to be removed off-site (such as use for aggregates), which would significantly reduce waste excavated rock arisings.

There would be a possibility that some excavated rock may contain contaminants from drilling and blasting, in which case it may require treatment on site or disposal to a suitable facility off-site in accordance with the relevant waste regulations.

Secondary wastes arising from activities during operation could include:

Concrete, gypsum and other rendering materials;

Waste buffer and backfill material – NRVB and bentonite;

Water from dust prevention, rock cutting and washing;

Dusts that accumulate from blasting/cutting;

Woods and metals (supporting members, reinforcing screens and bolts);

Plastics (membrane films and piping off-cuts used for drainage and seepage protection);

Packaging (blown foam, plastic ties, metal ties, wooden crates, pallets); and

Waste oils and drilling fluids.

15. Waste

A. Higher Strength Rock (cont)

Tertiary wastes could include broken bricks/blocks, nails/bolts, worn tools, canisters, drums (e.g. fuel, diesel, chemicals) and food waste and food packaging from on-site food consumption.



It is also expected that there would be some increase in general office waste from the surface facilities such as paper, organic canteen waste, packaging and possibly some electrical waste from the replacement and upgrades of computers/printers or other electrical products. The average waste figures for UK Government indicate that around 0.45 tonnes of waste is generated per employee.

Depending on their type, wastes may be sent to landfill, recycled or re-used, for example, as landscaping or as aggregates for construction projects. Drilling fluid is anticipated to be mechanically filtered and treated on site to remove sediment load. Depending on the fluid used, it may be recycled, discharged or removed for further off-site treatment. Some of the waste (some drilling fluid, small amounts of laboratory waste) may be treated as hazardous waste and would need to be handled in compliance with the relevant waste regulations.

Assumptions and uncertainties: As a detailed scheme design has not been finalised, at this stage specific quantities of likely waste arisings and the extent of any re-use or recycling cannot be determined.

The potential effect of the Derived Inventory Upper Inventory in relation to waste would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased GDF size, with an associated increase in the volume of construction materials required and construction waste generated, and due to the generation of surplus excavated rock to be removed off-site.

Proposed Mitigation/Enhancements: The mitigation measures recommended for the construction phase should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 15A of the construction phase assessment.

Summary of information requirements: Further information on the proposed scheme design, construction, buffer and backfill methods and options for the end use of excavated rock is required to enable a more detailed and accurate assessment of waste arisings to be made. Information on potential uses, markets and demand for waste excavated rock is required to inform the identification of potential options for the re-use of waste excavated rock. Similarly, information on the availability and capacity of waste management facilities in the vicinity of the site would be useful in identifying the best method of managing waste, whilst minimising transportation through the utilisation of local facilities possible.

B. Lower Strength Sedimentary Rock

The types of waste arisings and mitigation/enhancements for the lower strength sedimentary rock type would be the same as those identified for higher strength rock (refer to 15A. Higher Strength Rock).

However, the scale of waste arisings would differ when compared to the higher strength rock type. For the lower strength sedimentary rock type, the most significant waste stream would be excavated rock from the construction of the underground facilities; approximately 4,820,000m³ for the Derived Inventory Reference Case excluding Pu/U and 11,775,000m³ for the Derived Inventory Upper Inventory. For the lower strength sedimentary rock type it is proposed that 3,589,000m³ of the excavated rock would be used to construct surface bunds around the site, which would reduce the amount of waste excavated rock generated. However the surplus excavated rock, estimated to be approximately 1,231,000m³ for the Derived Inventory Reference Case excluding Pu/U and 8,186,000m³ for the Derived Inventory Upper Inventory, would be taken off-site. In the case of the lower strength sedimentary rock type, opportunities for the beneficial re-use of the excavated rock could be limited, as the rock may not have much commercial value.

In the case of the lower strength sedimentary rock type, waste buffer and backfill material would comprise NRVB and bentonite.

C. Evaporite Rock

The types of waste arisings and mitigation/enhancements for the evaporite rock type would be the same as those identified for higher strength rock (refer to 15A. Higher Strength Rock).

However, the scale of waste arisings would differ when compared to the higher strength rock type. For the evaporite rock type, the most significant waste stream would be excavated rock from the construction of the underground facilities; approximately 4,273,000m³ for the Derived Inventory Reference Case excluding Pu/U and 11,366,000m³ for the Derived Inventory Upper Inventory. None of the excavated rock would be used to construct surface bunds around the site, as the excavated rock would not be suitable for this.

15. Waste

C. Evaporite Rock (cont)

However, a proportion of the excavated rock would be retained on site within a dedicated storage area and used as backfill material, estimated to be around 1,172,121m³ for the Derived Inventory Reference Case excluding Pu/U and 2,816,121m³ for the Derived Inventory Upper Inventory for the backfilling of the HLW/SF disposal tunnels, shafts and common services area. The surplus excavated rock, estimated to be approximately 3,100,879m³ for the Derived Inventory Reference Case excluding Pu/U and 8,549,879m³ for the Derived Inventory Upper Inventory, would be



taken off-site. However, the potential exists for the beneficial use of the waste excavated rock to be removed off-site, which would significantly reduce waste excavated rock arisings. Halite evaporite rock is used widely in the UK as rock salt for winter de-icing of roads, and for chlorine production, food seasoning and medicinal purposes. Anhydrite is used in cement manufacture (i.e. Portland cement), as a source of sulphur and as a mineral filler in plastics, paints and paper. There is therefore the potential for the beneficial use of the remainder of the excavated rock to be removed off-site.

In the case of the evaporite rock type, waste buffer and backfill material would comprise MgO and crushed rock salt.

Headline Issues

- Generation of significant volumes of waste excavated rock spoil from the construction of the underground facility.
- Construction and general office waste arisings throughout the operation phase, including some potentially hazardous or special waste material from contaminated materials or testing.

For all host rock types, the potential effect of the Derived Inventory Upper Inventory in relation to waste would be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased GDF size, with an associated increase in the volume of excavated rock to be removed off-site and increase in the volume of construction materials required and construction waste generated.

The types of wastes generated would be similar for the different host rock types. However, the quantities of waste arisings would vary. Construction of a GDF within the evaporite would generate greater quantities of surplus excavated rock to be removed off-site. The Derived Inventory Reference Case excluding Pu/U evaporite rock type would generate 3,100,879m³ of excavated rock, compared to 1,231,000m³ for the lower strength sedimentary rock. For the higher strength rock Derived Inventory Reference Case excluding Pu/U, all of the excavated rock would be utilised on site and therefore there would be no surplus excavated rock. Similarly, the construction of a GDF within the evaporite rock for the Derived Inventory Upper Inventory would generate 8,549,879m³ of excavated rock, compared to 8,186,000m³ for the lower strength sedimentary rock and 6,640,921m³ for the higher strength rock.

Notwithstanding this, in the case of the higher strength and evaporite rock types, the potential exists for the beneficial use of the waste excavated rock to be removed off-site, which would significantly reduce waste excavated rock arising that would require disposal. Evaporite rock in particular is of commercial value. In the case of the lower strength sedimentary rock type, opportunities for the beneficial re-use of the excavated rock could be limited due to its low commercial value. The lower strength sedimentary rock type could therefore generate greater volumes of waste excavated rock due to the potential fewer opportunities for re-use. For all of the host rock types, if none of the surplus excavated rock could be re-used off-site for another purpose this would result in a significant waste stream.

16. Resource Use, Utilities and Services

A. Higher Strength Rock

Assessment of Effects:

For the higher strength rock type, the greatest level of resource use during operation would be associated with the construction of the ILW/LLW vaults and HLW/SF disposal tunnels (taking place concurrently with disposal throughout the operational phase) and the subsequent backfilling of the ILW/LLW vaults and HLW/SF disposal tunnels. For the higher strength rock type the following estimated quantities of buffer and backfill material would be required:

Approximately 204,000m³ of bentonite buffer to dispose of the Derived Inventory Reference Case excluding Pu/U HLW/SF and approximately 656,000m³ of bentonite buffer to dispose of the Derived Inventory Upper Inventory;

16. Resource Use, Utilities and Services

A. Higher Strength Rock (cont)

Approximately 1,000,000m³ of NRVB to backfill the Derived Inventory Reference Case excluding Pu/U ILW/LLW vaults and approximately 2,300,000m³ of NRVB to backfill the Derived Inventory Upper Inventory ILW/LLW vaults; and

Approximately 510,000m³ of bentonite and 1,190,000m³ of crushed rock to backfill the Derived Inventory Reference Case excluding Pu/U HLW/SF disposal tunnels and approximately 1,290,000m³ of bentonite and 3,010,000m³ of crushed rock to backfill the Derived Inventory



Upper Inventory HLW/SF disposal tunnels.

However, for the higher strength rock type, rock excavated during the construction of the underground facility would meet HLW/SF disposal tunnel crushed rock backfilling requirements, and therefore no crushed rock would need to be imported to the site for the backfilling of the HLW/SF disposal tunnels. However, bentonite would need to be imported to the site. It is noted that bentonite is not widely available in the UK and therefore may need to be shipped from abroad.

Key utilities and services that would be required during operation period include electricity, water supplies, communications systems, and ventilation systems for works underground. This could place additional demand on existing utilities and services, and there may be a requirement for new or additional utilities and services provision.

Throughout the operational period there would be an increase in energy use associated with the operation of plant machinery and equipment, site buildings and infrastructure (heating, lighting, canteen facilities, electronics etc), the operation of ventilation systems to ensure a supply of clean air, and lighting to allow safe working and for security purposes. Diesel generators may be used as a back-up power source but most of the energy demand would be met from the National Grid.

Water would be required throughout the operational phase for use in disposal tunnel construction activities (e.g. for cement mixing, drilling fluid, cleaning machinery, cooling equipment etc); for routine processes such as wash-down and decontamination; and for domestic purposes such as drinking water, canteen use, toilet and washing facilities and laundering protective clothing. In addition, a reliable and adequate water storage and distribution system would be required for fire fighting (refer to Sustainability Theme 5A). Sewerage systems for treatment of wastewater may also be required, depending on whether there is opportunity to connect to the existing network.

The significance of effects would be dependent to some extent on the location of the site, which would in turn dictate the availability of resources, utilities and services, and the sourcing of specific materials and their transport distance. Notwithstanding this, the potential effect of the Derived Inventory Upper Inventory would potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased GDF size, with an associated increase in utilities, services and resource use (particularly construction and backfill materials).

Assumptions and uncertainties: At this stage no site has been selected and detailed scheme design and construction, waste emplacement and backfill methods have not been finalised. Therefore, the specific quantities of resources required, the availability of resources and the sourcing of specific materials cannot be determined.

Proposed Mitigation/Enhancements: The mitigation measures recommended for the construction phase to prevent/minimise potential effects should be continued and maintained throughout the operational period; refer to the proposed mitigation in Sustainability Theme 16A of the construction phase assessment.

Summary of information requirements: Further information on the proposed scheme design, construction methods, waste emplacement and backfilling methods is required to enable a more detailed and accurate assessment of resource use to be made. Information on potential resource markets and demand is required to inform the assessment of effects. Site-specific information is required to determine the existing availability of utilities and services and thus the potential effect of the construction of a GDF on utilities and services provision.

B. Lower Strength Sedimentary Rock

The potential resources required for the lower strength sedimentary rock type and the potential mitigation/enhancements would be the same as those identified for higher strength rock (refer to 16A. Higher Strength Rock).

However, the scale of resource use would differ when compared to the higher strength rock type. The following estimated quantities of buffer/backfill material would be required for the lower strength sedimentary rock type:

Approximately 257,000m³ of bentonite (blocks and backfill) to dispose of the Derived Inventory Reference Case excluding Pu/U HLW/SF and approximately 731,000m³ of bentonite (blocks and backfill) to dispose of the Derived Inventory Upper Inventory.

16. Resource Use, Utilities and Services

B. Lower Strength Sedimentary Rock

Approximately 1,050,000 m³ of NRVB to backfill the Derived Inventory Reference Case excluding Pu/U ILW/LLW vaults and approximately 2,540,000m³ of NRVB to backfill the Derived Inventory Upper Inventory ILW/LLW vaults.



For the lower strength sedimentary rock type, none of the excavated rock would meet backfill requirements, and as a result all backfill material would need to be imported. Similar to the higher strength rock type, it is noted that bentonite is not widely available in the UK and therefore bentonite may need to be shipped from abroad. However, a smaller quantity of bentonite would be required when compared to the higher strength rock type.

C. Evaporite Rock

The potential resources required for the evaporite rock type and the potential mitigation/enhancements would be the same as those identified for higher strength rock (refer to 16A. Higher Strength Rock).

However, the scale of resource use would differ when compared to the higher strength rock type. The following estimated quantities of buffer/backfill material would be required for the evaporite rock type:

Approximately 144,000m³ of MgO sacks to dispose of the Derived Inventory Reference Case excluding Pu/U ILW/LLW and 356,000m³ of MgO sacks to dispose of the Derived Inventory Upper Inventory.

Approximately 872,000m³ of crushed rock salt to dispose of the Derived Inventory Reference Case excluding Pu/U HLW/SF and 2,516,000m³ of crushed rock salt to dispose of the Derived Inventory Upper Inventory, which is likely to be sourced from the excavated spoil.

However, for the evaporite rock type, rock excavated during the construction of the underground facility would meet HLW/SF disposal tunnel crushed rock salt backfilling requirements, and therefore no crushed rock salt would need to be imported to the site for this purpose. Due to the nature of the host geology there would not be any requirement for local or peripheral backfilling of the ILW/LLW vaults.

Headline Issues

- Requirement for significant quantities of construction materials and backfill material.
- Increase in resource use, utilities and services throughout the operational phase.

For all host rock types, the potential effect of the Derived Inventory Upper Inventory would be potentially greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased GDF size, with an associated increase in utilities, services and resource use (particularly construction and backfill materials).

Although the types of resources, utilities and services would be similar for the different host rock types, the extent of resource use would vary between the different host rock types. In terms of buffer and backfill resource use, in the case of higher strength rock and evaporite rock, requirements for crushed rock backfill material for backfilling of the HLW/SF disposal tunnels could be met on site using excavated rock. For the lower strength sedimentary rock type, none of the excavated rock would meet backfill requirements, and as a result all crushed rock backfill material would need to be imported. Notwithstanding this, the quantities of buffer/backfill material required to be imported to site could be greater for the higher strength rock type when compared to the other host rock types.

It is estimated that a greater quantity of bentonite, 714,000m³ and 1,946,000m³ in total, would be required for buffer/backfill for the higher strength rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively, compared to 257,000m³ and 713,000m³ of bentonite for lower strength sedimentary rock respectively. It is noted that bentonite is not widely available in the UK and therefore may need to be shipped from abroad. However, it is estimated that a greater quantity of NRVB, 1,050,000m³ and 2,540,000m³ in total, would be required for buffer/backfill for lower strength sedimentary rock (Derived Inventory Reference Case and Derived Inventory Upper Inventory respectively), compared to 1,000,000m³ and 2,300,000m³ of NRVB for higher strength rock respectively. No bentonite or NRVB would be required for the evaporite rock type. As only buffer material would be required to be imported for the evaporite rock (due to the nature of the host geology there would not be any requirement for ILW/LLW vault backfill material), resource use for buffering/backfilling could be much lower for the evaporite rock type.



Appraisal of the closure and post-closure phase

Once a decision is taken to close a Geological Disposal Facility (GDF), the underground facilities would be closed, and the surface facilities and infrastructure decommissioned. The site would then be restored to as near its preconstruction condition as practicable.

At the time of closure it is assumed that the Intermediate Level Waste (ILW)/Low Level Waste (LLW) vaults and High Level Waste (HLW)/Spent Fuel (SF) disposal tunnels would already have been backfilled and/or sealed and therefore it would only be necessary to progressively backfill the remaining underground roadways, facilities (workshops etc) and underground access tunnels (drift and/or shafts). Backfilling, sealing and closure of the remaining underground facilities is assumed to take place over a 10 year period.

A summary of the seal and backfill material assumptions for each illustrative geological disposal concept is provided below. For all of the host rock types, the only structures assumed to remain after site restoration are any surface bunds within the site.

Higher strength rock

The seal and backfill material utilised for the higher strength rock type would be as follows:

Low permeability seals of crushed rock would be placed in the underground access tunnels (drift and shafts). Mass backfill material for the higher strength rock type would comprise crushed rock.

It is estimated that 263,771m³ of crushed rock would be required for the backfilling of the access tunnels (drift and shafts), and 296,308m³ of crushed rock would be required for the mass backfilling of the common services area for both the Derived Inventory Reference Case excluding Plutonium (Pu)/Uranium (U) and Derived Inventory Upper Inventory. However, it is assumed that crushed rock from the excavation process would meet the drift, shaft and common services area backfilling requirements. Material backfill volumes for the remaining underground facilities and roadways are not available at this stage.

Lower strength sedimentary rock

The seal and backfill material utilised for the lower strength sedimentary rock type would be as follows:

Low permeability (compacted bentonite) seals would be placed in the underground access tunnels (drift and shafts) at the facility horizon.

Mass backfill for the remaining underground roadways, facilities and drift would comprise a mix of 30% bentonite and 70% sand with seals of highly compacted bentonite contained between bulkheads placed as required. The shafts would be filled with compacted bentonite.



It is estimated that 126,660m³ of backfill material would be required for the backfilling of the access tunnels (drift and shafts), and 73,749m³ of backfill material would be required for the mass backfilling of the common services area for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory.

Evaporite rock

The seal and backfill material utilised for the evaporite rock type would be as follows:

ILW/LLW vault access tunnels would be backfilled with crushed rock salt and then sealed off by a solid concrete wall. The HLW/SF disposal tunnel reception area would be in-filled with crushed rock salt and access tunnels associated with the disposal of HLW/SF would be backfilled with crushed rock salt, with periodic placement of dams to act as tunnel seals.

The shafts would be in-filled in one of two ways:

- Shaft in-fill would comprise salt saturated concrete at the shaft base with the monolith being sufficiently large enough to fill the shaft station excavations and the remainder of the fill would be various layers of compacted clay, crushed salt and asphalt water stops with concrete plugs above and below. The top 160m would be compacted earthen fill; or
- The shafts would be in-filled using multi-component seals using salt concrete and bitumen.

Mass backfill for the remaining underground roadways and facilities would comprise crushed rock salt.

It is estimated that 191,314m³ of crushed rock salt would be required for the backfilling of the access tunnels (shafts), and 108,807m³ of crushed rock salt would be required for the mass backfilling of the common services area for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory. However, it is assumed that crushed rock from the excavation process would meet the drift, shaft and common services area backfilling requirements. Material backfill volumes for the remaining underground facilities and roadways are not available at this stage.



Table D4 Appraisal of the closure and post-closure phase

1. Policies and Planning	
A. Higher Strength Rock	
<p>Assessment of Effects:</p> <p>At this stage, given the substantial time period that would have passed by the time a decision is reached to close the facility, the potential effect of the closure and post-closure phase in relation to policies and planning cannot be determined. The effect of the closure and post-closure phase on policies and planning would be dependant on the evolution of the future policy and planning framework.</p> <p>Assumptions and uncertainties: The effect of the closure and post-closure phase is uncertain due to the time period that would have lapsed by this stage.</p> <p>Proposed Mitigation/Enhancements:</p> <p>All closure and post-closure activities should adhere to relevant legislation and best practice guidance. Where possible minimum requirements should be exceeded.</p> <p>Summary of information requirements: The effects of the closure and post-closure phase in relation to policies and planning would need to be reviewed at a later stage in the programme prior to the commencement of any closure or post-closure activities.</p>	
B. Lower Strength Sedimentary Rock	
<p>The effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 1A. Higher Strength Rock). No effects in addition to those identified for the higher strength rock type are anticipated.</p>	
C. Evaporite Rock	
<p>The effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 1A. Higher Strength Rock). No effects in addition to those identified for the higher strength rock type are anticipated.</p>	
Headline Issues	
?	<ul style="list-style-type: none"> - The effect of the closure and post-closure phase is uncertain due to the time period that would have lapsed by this stage. <p>The effect of the closure and post-closure phase on policies and planning would be dependant on the evolution of the future policy and planning framework.</p>
2. Landscape and Visual	
A. Higher Strength Rock	
<p>Assessment of Effects:</p> <p>Backfilling, sealing and closure: During closure the remaining underground roadways, facilities and underground accesses would be backfilled. There would be the potential for surface activities associated with backfilling, sealing and closure to have a negative landscape and visual effect. However, any activities would be of a similar, or lesser, scale and nature as that of the proposed operational activities and it is assumed that closure activities would take place within the surface site area (assumed to be approximately 1.1km² (including surface facilities and infrastructure and up to 3,589,000m³ of excavated rock stored in bunds). By the closure phase it is also assumed that any visual screening and enhancements around the site would be well established. This could help to reduce visibility of the site and thus help reduce negative effects.</p> <p>Decommissioning and site restoration: Similar to backfilling, sealing and closure, the decommissioning of surface facilities following closure could also have a negative visual effect, although any effect would decrease as decommissioning progresses.</p>	



2. Landscape and Visual

A. Higher Strength Rock (cont)

Following the decommissioning of the surface facilities and infrastructure, it is assumed that the site would be restored to as near its preconstruction condition as practicable. The landscape and visual effect could be positive following restoration where surface structures that affect the visual amenity of local receptors are removed and where restoration works took into account existing landscape character, provided the restoration of the site did not result in the fragmentation or loss of any valued landscape elements or features. Given the substantial time period that would have passed since the construction of a GDF, there would be the potential for the GDF to have become an established element of the landscape, perceived as part of the current landscape character. Any planting undertaken as part of landscape and biodiversity mitigation would have become well established and could be regarded as a valued feature. It is also possible, although less likely, that surface facilities could also be regarded as valued features. Any loss of valued features could have a negative landscape and visual effect. The only structures that are anticipated to remain on site would be the surface bunds, therefore any landscape and visual effect associated with the presence of these bunds would remain.

Assumptions and uncertainties: The site surface area and the scale of surface development is assumed to be the same for the different waste inventories. The only structures assumed to remain after site restoration are any surface bunds within the site. It is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and a similar level of closure and post-closure activity would take place on the surface. Therefore there would not be any significant difference in potential landscape and visual effects between the different waste inventories.

The landscape and visual effect of site restoration is uncertain. The significance of decommissioning of the surface facilities and infrastructure and subsequent restoration of the site would depend on the scale and nature of the development and subsequent site restoration, the surrounding landscape and topography, the value of any landscape features within the site, the sensitivity of the surrounding landscape to such change, and the proximity and sensitivity of visual receptors.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 2A of the construction phase assessment.

Given the timescale that would have passed since the construction of a GDF, the restoration of the site to its previous state may be inappropriate. Therefore, careful consideration should be given to the potential restoration at the time of closure, with input from local stakeholders.

Where appropriate, any landscape features lost as a result of a GDF should be restored and habitat replanted like for like or to a better condition than previous, with maintenance carried out for a sufficient time to allow any habitat to establish.

Summary of information requirements: Given the period of time that would have lapsed substantial changes in landscape character may have taken place. Information on the landscape character and quality of the site and its surrounds would therefore be required. This would inform the identification of a suitable restoration programme.

B. Lower Strength Sedimentary Rock

Similar to the higher strength rock type, the surface site area for the lower strength sedimentary rock type is assumed to be approximately 1.1km², including surface facilities and infrastructure and up to 3,589,000m³ of excavated rock in bunds. The potential effects that could occur for the lower strength sedimentary rock type and the mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 2A. Higher Strength Rock).

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type and the mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 2A. Higher Strength Rock). However, for the evaporite rock type, the scale of any residual landscape and visual effects could differ when compared to the other host rock types. Similar to the other host rock types, the surface site area for the evaporite rock type would be approximately 1.1km², including surface facilities and infrastructure and surface screening bunds. However, in the case of the evaporite rock type none of the excavated rock would be stored in surface bunds. Instead the only excavated rock to be retained on site would be that required for backfilling, kept in a dedicated storage area. Although any surface screening bunds are anticipated to remain following site closure, it is anticipated that the dedicated storage area would be demolished as part of decommissioning, and therefore any residual landscape and visual effect could be less.



2. Landscape and Visual

Headline Issues

- Potential for surface activities associated with backfilling, sealing and closure of the underground facilities and the decommissioning of the surface facilities and infrastructure to have a negative landscape and visual effect (e.g. effects on surrounding landscape character and existing views).
- Potential effect of surface facility and infrastructure decommissioning and site restoration on current landscape character and visual amenity.

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For all of the host rock types would probably not be any significant difference in landscape and visual effects between the different waste inventories, as the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore a similar level of closure and post-closure activity would take place on the surface.

Similarly, there would probably not be any significant difference in landscape and visual effects associated with backfilling, sealing and closure and the decommissioning of the surface facilities and infrastructure between the different host rock types, as a similar level of activity would take place on the surface. However, following decommissioning and site restoration, the scale of any residual effect could differ between the different host rock types. Assuming that the dedicated storage area for excavated rock would be demolished as part of decommissioning for the evaporite rock type, any potential residual landscape and visual effect could be less for the evaporite rock type as only the surface screening bunds would remain on site. These could be of a smaller volume than the surface bunds for the higher strength rock and lower strength sedimentary rock types, which are assumed to comprise up to 3,589,000m³ of excavated rock.

3. Cultural Heritage

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: There would be the potential for surface activities associated with backfilling, sealing and closure to have a negative effect on the setting and amenity of above ground historic or archaeological features and landscapes (e.g. the movement of seal and backfill material). However, any closure works would be of a similar, or lesser, scale and nature as that of the proposed operational activities. By the closure phase it is also assumed that any visual screening and enhancements implemented during construction would have become well established; potentially reducing visibility into the site and helping to reduce any negative effects (refer to Sustainability Theme 2A).

No significant effects on above ground cultural heritage and archaeological sites and features or traditional activities would be anticipated as a result of backfilling, sealing and closure activities, as no further disturbance or development on the surface in addition to that during the construction and operational phases is anticipated. However, should surface closure activities extend outside of the surface site area (assumed to be approximately 1.1km², including surface facilities and infrastructure and up to 3,589,000m³ of excavated rock in bunds) there may be the potential for effects.

Similarly, no significant effects on sub surface and buried archaeological remains would be anticipated as a result of backfilling, sealing and closure activities, as no further excavation works would be undertaken.

Decommissioning and site restoration: Following closure, it is assumed that the surface facilities would be decommissioned and the site restored to as near its preconstruction condition as practicable (post-closure phase). Decommissioning and restoration of the site could have a positive effect on the setting of historic and archaeological sites and features in the surrounding area provided that restoration works took into account historic and archaeological assets and their settings and provided the decommissioning of the surface facilities and infrastructure did not result in the loss of any cultural heritage assets. Given the substantial time period that would have passed since construction, there would be the potential for a GDF to have become part of our cultural heritage, the sphere at Dounreay being an example of this. The decommissioning of the surface facilities could therefore potentially result in the loss of cultural heritage assets (although this would clearly depend on the cultural value placed on a GDF or its facilities).

Assumptions and uncertainties: The site surface area and the scale of surface development is assumed to be the same for the different waste inventories. The only structures assumed to remain after site restoration is any surface bunds within the site.



3. Cultural Heritage

A. Higher Strength Rock (cont)

It is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and a similar level of closure and post-closure activity would take place on the surface. Therefore there would probably not be a significant difference in potential effects between the different waste inventories.

At this stage no site has been selected and subsequently the effect of closure and post-closure activities on cultural heritage and archaeology is uncertain. The potential for effects would depend on the scale and nature of the development and subsequent site restoration, the proximity of the site to any cultural historic and archaeological sites, features and landscapes, the condition and sensitivity of the site/feature/landscape affected and the level of disturbance or loss.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 3A of the construction phase assessment.

Careful consideration should be given to the effect of any restoration works on cultural historic and archaeological assets and their settings at the time of closure. Any opportunities to restore or enhance cultural historic and archaeological assets and their settings as part of restoration works should be pursued.

Given the timescale that would have passed since the construction of a GDF, surface facilities and infrastructure may have become part of our cultural heritage. Therefore, careful consideration should be given to their cultural heritage value and appropriate protection afforded where necessary.

Summary of information requirements: Given the period of time that would have lapsed there is the potential for the surface facilities and infrastructure to have become part of the cultural heritage. The cultural heritage value of the surface facilities would therefore need to be determined.

B. Lower Strength Sedimentary Rock

The potential effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 3A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.

Similar to the higher strength rock type, the surface site area for the lower strength sedimentary rock type is assumed to be approximately 1.1km², including surface facilities and infrastructure and up to 3,589,000m³ of excavated rock stored in bunds.

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type and the mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 3A. Higher Strength Rock).

However, for the evaporite rock type, the scale of any residual effects on the setting of cultural historic and archaeological sites could differ when compared to the other host rock types.

Similar to the other host rock types, the surface site area for the evaporite rock type would be approximately 1.1km², including surface facilities and infrastructure and surface screening bunds. However, in the case of the evaporite rock type none of the excavated rock would be stored in surface bunds. Instead the only excavated rock to be retained on site would be that required for backfilling, which would be kept in dedicated storage area. Although any surface screening bunds are anticipated to remain following site closure, it is anticipated that the dedicated storage area would be demolished as part of decommissioning, and therefore any residual effect on the setting of cultural, historic and archaeological features and landscapes could be less.



3. Cultural Heritage

Headline Issues

- Potential for surface decommissioning and site restoration to have an effect on the setting of cultural historic and archaeological sites or features and landscapes.

For all of the host rock types there would probably not be any significant difference in effects between the different waste inventories, as the surface site area for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and a similar level of closure and post-closure activity would take place on the surface.

Similarly, there would probably not be any significant difference in effects associated with the backfilling, sealing and closure of the underground facilities and the decommissioning of the surface facilities and infrastructure between the different host rock types, as a similar level of activity would take place on the surface.

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However, following decommissioning and site restoration, the scale of any residual effect could differ between the different host rock types. Assuming that the dedicated storage area for excavated rock would be demolished as part of decommissioning for the evaporite rock type, any potential residual effect on the setting of cultural, historic and archaeological assets could be less for the evaporite rock type as only the surface screening bunds would remain on site. These could be of a smaller volume than the surface bunds for the higher strength and lower strength sedimentary rock types, which are assumed to comprise up to 3,589,000m³ of excavated rock.

At this stage no site has been selected and subsequently the effect of closure and post-closure activities on cultural heritage and archaeology is uncertain. The potential for effects would depend on the scale and nature of the development and subsequent site restoration, the proximity of the site to any cultural historic and archaeological sites, features and landscapes, the condition and sensitivity of the site/feature/landscape affected and the level of disturbance or loss.

4. Geology and Soils

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: At the closure and post-closure phase no significant effects on sites of recognised importance for their geological value (e.g. SSSI or RIGS) are anticipated, as no further surface disturbance or development would take place. However, should activities extend outside of the development footprint for the construction and operation phase there may be the potential for negative effects on such sites.

Similarly, there would be the potential for the presence of the underground facility within higher strength rock to result in the loss or sterilisation of a minerals resource or minerals reserve (where a site is covered by valid planning permissions for the extraction of minerals). The scale of the underground facility would not alter and would remain for the foreseeable future, therefore any effects on sites of geological importance and minerals resources or reserves resulting from the presence of the facility within the host rock would remain. The potential effect of the Derived Inventory Upper Inventory could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility footprint, which would affect a greater area. The footprint of the underground facility for the higher strength rock type is assumed to be at least 4.3km² for the Derived Inventory Reference Case excluding Pu/U and 9.8km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). The magnitude of effect would potentially be high given the area and volume of rock affected and the duration of the effect. However, the significance would be dependent on the quality and type of excavated rock, its availability and its usage.

As noted in the operational phase assessment, the physical presence of waste packages within the host rock would probably not have any effect on the physical stability or the background level of seismicity of the surrounding geology. There would be some potential risk to waste container integrity from structural failures. However, sufficient rock support of a high standard would be provided to ensure long-term structural stability. There would be the potential for heat from the high level radioactive wastes to damage engineered barriers, backfill and host geology. However, the waste disposal areas would be designed to ensure, as far as possible, that waste temperatures did not exceed specifications. The waste packages would also be designed to ensure they retained their integrity for many hundreds of years. The behaviour of corrosive products at the interface between the steel canister and backfill require further investigation. Consequently the effects are uncertain at this stage.



4. Geology and Soils

A. Higher Strength Rock (cont)

Decommissioning and site restoration: There would be the potential for decommissioning and site restoration works to have an effect on soils stored on site where they are moved or utilised for site restoration works, and for works to introduce some low level contamination (e.g. re-fuelling and oil spillages).

However, any potential negative effects could be sufficiently mitigated where best practice guidance on soil handling and storage. Effects could be beneficial where stored soils are used in the restoration process and restored to their condition prior to construction.

Assumptions and uncertainties: The site surface area and the scale of surface development is assumed to be the same for the different waste inventories. The only structures assumed to remain after site restoration is any surface bunds within the site.

It is assumed that sufficient rock support of a high standard would be provided to ensure the long-term structural stability of the host rock and that the waste packages would be designed to retain their structural integrity.

It is assumed that the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and therefore there would probably not be any difference in potential effects on soils between the different waste inventories.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 4A of the construction phase assessment.

For high quality reclamation the dump truck and back acter method is recommended (soils to be lifted by back acter in separate layers and transported by dump truck), as this is considered to minimise damage to soil materials during soil handling operations.

Soils should be restored onto a stable but permeable substrate. For the reclamation of high quality land, slopes should not exceed 1 in 8. Minimum recommended slopes for restored agricultural land are 1:100. Following restoration of a GDF site to its pre-construction condition, a suitable aftercare regime should be put in place.

Opportunities for the beneficial re-use of excavated rock retained on site within the surface bunds should be explored. For example, excess excavated rock could be exported via railhead for use as aggregates/construction materials. The transport implications of exporting excavated rock off-site would need to be considered carefully. Where possible, the disposal of excavated rock to landfill should be avoided. The available options should be subject to environmental assessment.

Summary of information requirements: No further information in addition to that identified for the construction phase has been identified (refer to the construction phase assessment for 4A. Higher Strength Rock).

B. Lower Strength Sedimentary Rock

For the lower strength sedimentary rock type, the potential effects that could occur and the potential mitigation/enhancements relating to soils and the physical and chemical stability of the host rock are considered to be the same as those identified for higher strength rock (refer to 4A. Higher Strength Rock).

However, the scale of any effects associated with excavated rock could differ when compared to the higher strength rock type. The potential effect of the lower strength sedimentary rock type on sites of geological importance could be greater when compared to the other host rock types, due to the increased size of the underground facility footprint, which is assumed to be at least 7.8km² for the Derived Inventory Reference Case excluding Pu/U and 19.5km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area).

In the case of the lower strength sedimentary rock type, no significant effects on minerals resources or minerals reserves associated with the presence of the underground facility within the host rock are anticipated, due to its low commercial value. However, significant quantities of bentonite (refer to Sustainability Theme 16B) would need to be imported for the backfilling of the HLW/SF disposal tunnels, which could have an effect on minerals resources and reserves elsewhere.



4. Geology and Soils

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 4A. Higher Strength Rock).

However, the potential effect of the evaporite rock type on sites of geological importance and minerals resources/reserves could be greater when compared to higher strength rock, due to the increased size of the underground facility footprint, which is assumed to be at least 6.5km² for the Derived Inventory Reference Case excluding Pu/U and 18.4km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). Therefore a greater area of sites of geological importance or minerals resources/reserves could be affected.

Headline Issues

-	<ul style="list-style-type: none"> - Potential for site restoration works to have an effect on soil resources.
?	<ul style="list-style-type: none"> - Potential for the underground facility within the higher strength rock and evaporite rock to result in the continued sterilisation of a minerals resource, or minerals reserve where a site is covered by valid planning permissions for the extraction of minerals <p>There would probably not be any significant difference in potential effects on soils between the different waste inventories and different host rock types, as the surface site area is assumed to be the same (approximately 1.1km², assuming that the surface site area for the evaporite rock type includes surface screening bunds).</p> <p>Taking account of scale, there is the potential for the lower strength sedimentary rock type to have a greater impact upon sites of geological importance when compared to the higher strength rock and evaporite rock types, as the underground facility footprint would be greater (7.8km² for the Derived Inventory Reference Case and 19.5km² of the Derived Inventory Upper Inventory) when compared to higher strength rock (4.3km² and 9.8km² respectively) and evaporite rock (6.5km² and 18.4km² respectively).</p> <p>In the case of the higher strength and evaporite host rock types the presence of the underground facility could sterilise a mineral resource or reserve. The evaporite rock type could potentially have the greatest effect on minerals resources or reserves, due to the increased size of the underground facility footprint when compared to the higher strength rock type. Although the underground facility for the lower strength sedimentary rock type would have the greatest footprint, the lower strength sedimentary rock type is unlikely to have a direct effect on mineral resources or mineral reserves, due to its low commercial value. However, during the operational phase in the case of the lower strength sedimentary rock type, significant quantities of bentonite (refer to Sustainability Theme 16C) would need to be imported for the backfilling of the HLW/SF disposal tunnels, which could have an effect on minerals resources and reserves elsewhere.</p>

5. Water

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: During backfilling, sealing and closure water use would be limited to that used for routine processes (e.g. wash-down and cleaning machinery, and for domestic purposes such as toilet and washing facilities). During backfilling, sealing and closure, surface run-off on the site would continue to be collected via the on site drainage system and treated prior to discharge. Any discharges, particularly run-off from the surface bunds, would have the potential to affect the water quality and/or rate of flows of receiving waters. There would also be the potential for contamination of surface water and groundwater through accidental spillage of materials or chemicals. However, the risk of contamination from accidental spillage would be reduced as the level of activity on site would be less.

The presence of the underground facility within the host rock, and any grouting/lining in the drift, shafts and tunnels as required, would reduce the transmissive capacity of water bearing formations (aquifers) on a localised scale, acting as a barrier to normal flow patterns. The presence of large volumes of Nirex Reference Vault Backfill (NRVB) in the underground facility would also have the potential over time to create a plume of high pH alkaline groundwater down the hydraulic gradient from the ILW/LLW vaults.



5. Water

A. Higher Strength Rock (cont)

Due to the increased size of the underground facility and associated increase in NRVB used, the Derived Inventory Upper Inventory could have a greater effect on groundwater when compared to the Derived Inventory Reference Case excluding Pu/U.

Decommissioning and site restoration: Similar to backfilling, sealing and closure, water use would be required for routine processes. Water use would reduce as decommissioning progresses, reducing activity on site. Following decommissioning, the site would be restored to as near its preconstruction condition as practicable with a similar surface run-off regime to that originally present.

Assumptions and uncertainties: The site surface area and the scale of surface development is assumed to be the same for the different waste inventories. The only structures assumed to remain after site restoration is any surface bunds within the site. It is assumed that the surface run-off on site would be restored to a similar regime to that originally present.

As noted in the construction phase assessment, it is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same of that for the Derived Inventory Upper Inventory and therefore there would probably not be any significant difference in potential surface run-off and flood risk effects between the different waste inventories.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 5A of the construction phase assessment.

All boreholes no longer required for ongoing monitoring should to be decommissioned in accordance with best practice guidance (i.e. Environment Agency and National Groundwater and Contaminated Land Centre guidance, Decommissioning Redundant Boreholes and Wells or equivalent). The correct sealing of boreholes within overlying strata is important to prevent rapid migration pathways.

Site restoration should ensure a similar surface run-off regime to that originally present.

Summary of information requirements: No further information in addition to that identified for the construction phase has been identified (refer to the construction phase assessment for 5A. Higher Strength Rock).

B. Lower Strength Sedimentary Rock

The potential effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 5A. Higher Strength Rock).

However, the scale of any effects associated with excavated rock could differ when compared to the higher strength rock type.

In addition to the potential effects for the higher strength rock, there is the potential that low strength sedimentary rocks may contain sufficient sulphide to cause acid generating reactions on exposure to air and water, giving rise to the potential for contamination of soils and surface water courses with low pH waters. This risk could be mitigated by limiting exposure to air and water by the rapid covering of excavated material.

The footprint of the underground facility for the lower strength sedimentary rock type would be greater than that of the other host rock types. It is assumed to be at least 7.8km² for the Derived Inventory Reference Case excluding Pu/U and 19.5km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). The potential effect of a GDF within lower strength sedimentary rock on groundwater could therefore be greater than that of the other host rock types due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows and groundwater quality.

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 5A. Higher Strength Rock).

However, the scale of any effects associated with excavated rock could differ when compared to the higher strength rock type.

However, in addition to the potential effects for the higher strength rock type, depending on the evaporite host rock type, any excavated host rock stored on the surface could present a potential pollution risk. The evaporite rock type halite is highly soluble in fresh water and therefore if excavated halite rock were to come in contact with water the potential would exist for the contamination of surface water courses with high chloride waters. This could be mitigated for by storage under cover. The evaporite rock anhydrite, however, is less so, and therefore the pollution risk would be less than that of halite.



5. Water

C. Evaporite Rock (cont)

Notwithstanding this, once in the underground facility the crushed rock backfill material is not anticipated to have any effect on groundwater, as crushed rock backfill material would be used, which is the same as the host rock. Notwithstanding this, once in the underground facility the crushed rock backfill material would not have any effect on groundwater, as crushed rock backfill material would be used, which would be the same as the host rock.

Permeability varies by rock type; within evaporite rock migration pathways are virtually absent. However, the footprint of the underground facility for the evaporite rock type would be greater than that of the higher strength rock type. The underground facility footprint for the evaporite rock type is assumed to be at least 6.5km² for the Derived Inventory Reference Case excluding Pu/U and 18.4km² for the Derived Inventory Upper Inventory (taking account of the size of the ILW/LLW vaults and HLW/SF disposal tunnels and the roadways and support area). The potential effect of a GDF within evaporite rock on groundwater could therefore be greater than that of the higher strength rock type due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows and groundwater quality.

Headline Issues

- Water use throughout the closure and post-closure phase, which has the potential to affect water availability for other licensed abstractors, or for environmental flow targets to be adversely affected.
- Potential for closure and post-closure activities to affect water quality and/or the rate of flows of receiving waters.
- Potential for the presence of the underground facility to affect groundwater flows.
- Potential for the presence of large volumes of NRVB in the underground facility for the higher strength and lower strength sedimentary rock types to create a plume of high pH alkaline groundwater down the hydraulic gradient from the ILW/LLW vaults over time.

For all three host rock types, the potential effect of the Derived Inventory Upper Inventory on groundwater could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility footprint, which could have a greater effect on groundwater flows.

For both the higher and lower strength sedimentary rock types, due to the increased size of the underground facility and associated increase in NRVB used, there would be the potential for the Derived Inventory Upper Inventory to have a greater effect on groundwater from the presence of NRVB when compared to the Derived Inventory Reference Case excluding Pu/U. The potential long-term effect of the higher strength rock type on groundwater associated with the use of NRVB could be greater when compared to the lower strength sedimentary rock type, as a greater volume of NRVB would be used. In the case of the evaporite rock type, the crushed rock backfill material would not have any long-term effects on groundwater, as crushed rock backfill material would be used, which would be the same as the host rock.

There would be the potential for the different host rock types to affect the scale of any effects on water resources and flood risk. In the case of lower strength sedimentary rock and evaporite rock (depending upon its type), due to the nature of the host rock, there would be the potential for excavated rock to negatively affect water quality. Lower strength sedimentary rock may contain sufficient sulphide to cause acid generating reactions on exposure to air and water, giving rise to the potential for contamination of soils and surface water courses with low pH waters. Similarly, the evaporite rock type halite is highly soluble in fresh water and therefore if excavated halite rock were to come in contact with water the potential would exist for the contamination of surface water courses with high chloride waters. The evaporite rock anhydrite, however, is less so, and therefore the pollution risk would be less than that of halite.

Permeability varies by rock type, with a greater potential for faults and fracturing within the higher strength rock. Lower strength sedimentary rock such as indurated clay has minimal fracturing, and within evaporite rock migration pathways are virtually absent. However, as the selection of a suitable host environment would be based on low groundwater flows and at any suitable site the potential for significant groundwater ingress would be low. Notwithstanding this, the lower strength sedimentary rock type could potentially have the greatest effect on groundwater flows as the underground facility footprint (7.8km² and 19.5km² for the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory respectively) would be greater when compared to the higher strength rock type (4.3km² and 9.8km² respectively) and evaporite rock type (6.5km² and 18.4km² respectively).



6. Biodiversity, Flora and Fauna

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: During the closure phase the remaining underground roadways, facilities and underground access tunnels (drift and shafts in the case of higher strength rock) would be backfilled and sealed. As all surface activities associated with backfilling, sealing and closure would take place within the surface site area, no further effects on biodiversity (i.e. habitat loss due to development, habitat change and disturbance to fauna) would be anticipated to arise from land take. However, should these activities extend outside of the surface site area there may be the potential for effects.

There would be the potential for backfilling, sealing and closure activities to disturb or displace conservation notable species from the site and its surrounds; the significance of which would be dependant on the location chosen for a GDF and its biodiversity value. Disturbance or displacement of fauna is likely to be caused by a range of factors such as noise, human presence and light pollution, and has the potential to reduce the rates of breeding success and survival resulting in detectable falls in the size of local populations of fauna.

The accidental release or spillage of substances (e.g. diesel) and silt laden run-off may also affect notable flora and fauna, as could any increased deposition of pollutants associated with heavy traffic movements.

However, closure works would be of a similar, or lesser, scale and nature as that of the proposed operational activities. Given the time period that a GDF would have been in operation, it is not anticipated that there would be any increase in disturbance and displacement as species in the site and the surrounds would have become accustomed to activities on site.

Decommissioning and site restoration: Following backfilling, sealing and closure, it is assumed that the surface facilities and infrastructure would be decommissioned and the site would be restored to as near its preconstruction condition as practicable (post-closure phase). Given the substantial time period that would have passed since construction, there would be the potential for negative effects where any visual screening and enhancements around the site were removed, as any planting undertaken as part of landscape and biodiversity mitigation would probably have become well established and may be of biodiversity value.

Assumptions and uncertainties: The site surface area and the scale of surface development is assumed to be the same for the different waste inventories. The only structures assumed to remain after site restoration is any surface bunds within the site.

It is assumed that the surface site area and scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that for the Derived Inventory Upper Inventory and as such as similar level of closure and post-closure activity would take place on the surface. Therefore there would probably not be any significant difference in effects between the different waste inventories.

At this stage no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the biodiversity value of the site and its surrounds, the sensitivity of any habitats/species present, and the level of habitat disturbance or loss.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 6A of the construction phase assessment.

Prior to site restoration, it is recommended that surveys are undertaken (walkover surveys and detailed species specific surveys) as appropriate to determine the biodiversity value of the site. Valuable biodiversity habitat or features should be retained where possible and any loss minimised as far as practically possible. Habitat fragmentation should be avoided by minimising the removal of habitat wildlife corridors.

Any opportunities for habitat improvement and enhancement (e.g. any opportunities to contribute towards or meet Local Biodiversity Action Plan targets) should be pursued in consultation with Natural England, the local Wildlife Trust (or equivalents) and other appropriate bodies.

The reinstatement of the site should ensure that habitat is restored to its previous condition and where possible enhanced into a more favourable condition. A management plan should be put in place where necessary to ensure the long-term success of any biodiversity mitigation and enhancements.

Summary of information requirements: Given the period of time that would have lapsed there is the potential for landscape features and undeveloped areas within the site to have become of biodiversity value, which would therefore need to be determined. Surveys should be undertaken as appropriate.



6. Biodiversity, Flora and Fauna

B. Lower Strength Sedimentary Rock

The potential effects on biodiversity that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 6A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The potential effects on biodiversity that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 6A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.

Headline Issues

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- Potential for the disturbance/displacement of conservation notable species from the sites and their surrounds as a result of closure and post-closure activities (e.g. such as noise, human presence and light pollution).
- Potential for decommissioning of the surface facilities and infrastructure and site restoration to have an effect on site biodiversity (positive or negative), depending on the nature of the site restorations and the retention or removal of any habitat within the site.

There would probably not be any significant difference in effects between the different waste inventories and different host rock types, as the surface site area and the scale of surface development is assumed to be similar and a similar level of activity would take place on the surface.

At this stage no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the biodiversity value of the site and its surrounds, the sensitivity of any habitats/species present, and the level of habitat disturbance or loss.

7. Traffic and Transport

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: Activities associated with backfilling, sealing and closure would result in an increase in traffic movements on the local road network (e.g. Heavy Goods Vehicles (HGVs) transporting backfill material, and personnel vehicles).

Decommissioning and site restoration: Similar to closure of the underground facility, decommissioning activities would also result in traffic movements (e.g. decommissioning plant, HGVs transporting waste and personnel vehicles).

Effects that could be considered as potentially significant on the road network include severance to pedestrians/cyclists induced by the flow of vehicles along a road, driver delay, pedestrian/cyclist amenity, and accidents and safety as a result of an increase in traffic.

During closure and post-closure the greatest number of traffic movements generated is anticipated to be associated with the import of mass backfill material required for backfilling the remaining underground facilities and infrastructure and the removal of waste from decommissioning surface facilities and infrastructure.

However, although closure and post-closure activities would generate traffic, it is anticipated that the activities would be of a lesser scale to that during the proposed operational phase. It is also assumed that no crushed rock backfill material for backfilling the drift and shaft, and common services area would need to be imported to the site as excavated rock from the construction of the underground facility would meet crushed rock backfill requirements for these areas.



7. Traffic and Transport

A. Higher Strength Rock (cont)

It is unknown whether crushed rock backfill requirements for mass backfilling the remaining underground roadways and facilities could met using surplus excavated rock from the construction of the underground facility, as estimate quantities of mass backfill material required for the remaining underground roadways and facilities are not available at this stage.

The potential traffic and transport effect of backfilling, sealing and closure of a GDF for the Derived Inventory Upper Inventory could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with a potential increase in the volume of backfill material required.

Assumptions and uncertainties: It is assumed that all backfill material and any waste associated with closure and post-closure activities would be transported to and from the site via road. It is also assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the sites and may pass close to sensitive receptors such as residential areas.

As the footprint of surface development for the Derived Inventory Reference Case excluding Pu/U would be similar to that of the Derived Inventory Upper Inventory and a similar level of activity would take place on the surface there would probably not be any significant difference in potential traffic effects between the different waste inventories associated with decommissioning and site restoration.

At this stage it is difficult to ascertain the extent of the traffic and transport effects as limited information is available. The significance of the traffic and transport effects of the closure and post-closure phase would depend on the location of the site, the extent of use of rail facilities, the sensitivity of the local highway network, the location of mass backfill materials and the end use of decommissioned surface facilities and infrastructure and any waste material removed off-site. This may affect the range of measures that are implemented to mitigate traffic related environmental effects.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 6A of the construction phase assessment.

Where practicable provision should be made for the transport of any plant, mass backfill materials and waste via rail or sea. Any effect on the road network would be significantly reduced where rail or sea is used as the sole or primary means of transport.

Prior to decommissioning, consideration should be given to the potential longer term use of any transport infrastructure provided.

Any opportunities for wider industrial/commercial use of any transport infrastructure following post-closure should be explored.

Any access routes in place prior to construction should be restored to pre-construction condition and enhanced wherever possible.

Contributions could be made towards improving the road network and public rights of way where appropriate.

Summary of information requirements: Site-specific information is required to establish the likelihood of any effects on traffic, such as the proposed transport method, the capacity and sensitivity of the existing road network, and traffic routing. A Traffic Assessment should be undertaken to determine the potential effects and required mitigation.

B. Lower Strength Sedimentary Rock

The potential traffic and transport effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 7A. Higher Strength Rock).

However, the scale of the effects would differ when compared to the higher strength rock type. In the case of the lower strength sedimentary rock, the excavated rock retained on site in surface bunds would not meet backfill requirements and consequently none would be used for mass backfilling.

Mass backfill material would therefore need to be imported to the site, which is likely to generate a significant number of transport movements. It is noted that bentonite, which would be required for mass backfilling for the lower strength sedimentary rock type, is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport impact.



7. Traffic and Transport

C. Evaporite Rock

The potential traffic and transport effects that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 7A. Higher Strength Rock).

Similar to higher strength rock, it is assumed for the evaporite rock type that no crushed rock backfill material for backfilling the drift and shaft, and common services area would need to be imported to the site as excavated rock stored on site from the construction of the underground facility would meet crushed rock backfill requirements for these areas, reducing the need to import any mass backfill for these areas.

It is unknown whether crushed rock backfill requirements for mass backfilling the remaining underground roadways and facilities could met using surplus excavated rock from the construction of the underground facility, as estimate quantities of mass backfill material required for the remaining underground roadways and facilities are not available at this stage.

Headline Issues

- Traffic movements on the local road network throughout the closure and post-closure phase, with potential severance, driver delay, pedestrian/cyclist amenity and safety implications.

For all of the host rock types the potential traffic and transport effect of closure and post-closure for the Derived Inventory Upper Inventory could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with a potential increase in the volume of mass backfill material required.

The potential traffic and transport effects that could occur would be the same for each of the host rock types. However, the scale of any effects could differ. For both the higher strength rock and evaporite rock types, excavated rock could meet crushed rock access tunnel (drift and/or shafts) and common services area mass backfilling requirements, which would negate the need to import any crushed rock for backfilling of these areas. In the case of the lower strength sedimentary rock, the excavated rock would not meet backfill requirements and consequently none of the excavated rock would be used for backfilling. Therefore all mass backfill material would need to be imported to the site, which could generate a significant number of transport movements. Based on current known backfill estimates, the traffic effects of the lower strength sedimentary rock type could therefore be greater than that of the higher strength rock and evaporite rock types. In addition, bentonite, which would be required for mass backfilling for the lower strength sedimentary rock type, is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any potential transport impact.

It should be noted that estimate quantities of backfill material required for the remaining underground roadways and facilities are not available at this stage. For the higher strength and evaporite rock types, it is unknown whether crushed rock backfill requirements for backfilling the remaining underground roadways and facilities could be met using surplus excavated rock from the construction of the underground facility. However, surplus excavated rock would remain on site in surface bunds and therefore there could be the potential that some or all of the excavated rock could be used for this purpose.

8. Air Quality

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: As noted in Sustainability Theme 7A, there would be an increase in traffic movements on the local road network as a result of backfilling, sealing and closure activities. Exhaust emissions from traffic could lead to a decrease in local air quality, particularly from nitrogen oxides, nitrogen dioxide and particulates.

Dust generated from backfill, sealing and closure, particularly the movement of mass backfill material could also have an effect on local air quality if unmanaged.

In the case of the higher strength rock, the use of excavated rock retained on site for backfilling of the underground access tunnels (drift and shafts) and common services area would negate the need to transport any crushed rock backfill material to the site for this purpose (refer to Sustainability Theme 7A), the transport of which could otherwise affect local air quality.



8. Air Quality

A. Higher Strength Rock (cont)

It is unknown whether crushed rock backfill requirements for mass backfilling the remaining underground roadways and facilities could met using surplus excavated rock from the construction of the underground facility, as estimate quantities of mass backfill material required for the remaining underground roadways and facilities are not available at this stage.

The effect of backfilling, sealing and closure for the Derived Inventory Upper Inventory in relation to transport related air quality effects could potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with a potential increase in the volume of mass backfill material required to be imported to the site.

Decommissioning and site restoration: Similar to closure, decommissioning activities would also result in an increase in traffic and dust generation, which could affect local air quality. Exhaust emissions from plant and diesel generators, used to supply non mains power associated with decommissioning and site restoration activities, may also contribute to emissions in particulate matter and gaseous pollutants (particularly nitrogen dioxide and carbon dioxide (CO₂)).

Assumptions and uncertainties: Refer to Sustainability Theme 7A for traffic and transport assumptions.

It is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and a similar level of decommissioning and site restoration would take place on the surface. Therefore there would probably not be a significant difference in potential transport related air quality effects between the different waste inventories.

As a site has not been selected at this stage, the extent of any air quality effects associated with the closure and post-closure phase is uncertain. The magnitude and significance of effects of emissions to air would depend on the location of the site and the sensitivity of the local environment, the proposed traffic routing and journeys, the extent of use of rail facilities, the location of backfill materials and the end use of decommissioned surface facilities and infrastructure and any waste material removed off-site. Notwithstanding this, all equipment would comply with UK Government emissions regulations and would be sited to minimise effects on nearby sensitive receptors.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 8A of the construction phase assessment.

Summary of information requirements: Further information on GDF design and materials, and decommissioning procedures is required to establish the likelihood of any effects on local air quality and necessary mitigation.

B. Lower Strength Sedimentary Rock

The potential air quality effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 8A. Higher Strength Rock).

However, the scale of any effects could differ when compared to the higher strength rock type. In the case of the lower strength sedimentary rock, as the lower strength sedimentary excavated rock from the construction of the underground facilities would not meet mass backfill requirements, consequently backfill material would need to be imported to the site. In addition, it is noted that bentonite, which would be required for mass backfilling for the lower strength sedimentary rock type, is not widely available in the UK and therefore bentonite may need to be shipped from abroad, which would increase any potential transport related air quality impact. There is therefore a possibility that transport related air quality effects associated with the import of mass backfill material could be greater for the lower strength sedimentary rock type.

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for the higher strength rock (refer to 8A. Higher Strength Rock).

Similar to the higher strength rock type, it is assumed for the evaporite rock type that no crushed rock backfill material for backfilling the drift and shaft, and common services area would need to be imported to the site as excavated rock stored on site would meet crushed rock backfill requirements for these areas. It is unknown whether crushed rock requirements for mass backfilling the remaining underground roadways and facilities could be met using surplus excavated rock, as estimate quantities of mass backfill material required are not available at this stage. Therefore the potential transport related air quality effects associated with the import of any mass backfill material cannot be ascertained.



8. Air Quality

Headline Issues

- Potential for exhaust emissions from traffic to negatively affect local air quality, particularly transport associated with the import of backfill material and/or the removal of waste from decommissioning activities on site.
- Potential for dust generated during closure and post-closure activities to negatively affect local air quality if unmanaged.

For all of the host rock types, the effect of backfilling, sealing and closure of the Derived Inventory Upper Inventory in relation to transport related air quality effects could potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with a potential increase in the volume of backfill material required.

As noted in Sustainability Theme 7A, based on current known backfill estimates traffic generation could be much greater for the lower strength sedimentary rock type when compared to the higher strength and evaporite rock types, due to the requirement to import all mass backfill material. The potential transport related air quality effects could therefore potentially be greater for the lower strength sedimentary rock type. For the lower strength sedimentary rock type it is also noted that bentonite would need to be imported for the backfilling of the HLW/SF disposal tunnels. Bentonite is not widely available in the UK and therefore bentonite may need to be shipped from abroad, which would increase any potential transport related air quality impact.

It should be noted that estimate quantities of backfill material required for the remaining underground roadways and facilities are not available at this stage. For the higher strength and evaporite rock types, it is unknown whether crushed rock backfill requirements for backfilling the remaining underground roadways and facilities could be met using surplus excavated rock from the construction of the underground facility. However, surplus excavated rock would remain on site in surface bunds and therefore there could be the potential that some or all of the excavated rock could be used for this purpose.

9. Climate Change

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: The emission of carbon dioxide (due to the direct or indirect combustion of fossil fuel) from traffic and plant and the embodied energy in backfill materials used would contribute to climate change. When considering the source of material used, the distance and method of transportation would have a direct effect on overall carbon emissions (e.g. the different emissions associated with transport by road, rail or ship).

In the case of the higher strength rock, the use of excavated rock retained on site for backfilling of the underground access tunnels (drift and shafts) and common services area would negate the need to import any crushed rock backfill material to the site for this purpose (refer to Sustainability Theme 7A), the transport of which could otherwise result in carbon emissions. It is unknown whether crushed rock backfill requirements for mass backfilling the remaining underground roadways and facilities could be met using surplus excavated rock from the construction of the underground facility, as estimate quantities of mass backfill material required for the remaining underground roadways and facilities are not available at this stage.

The effect of backfilling, sealing and closure of the Derived Inventory Upper Inventory in relation to transport related carbon emissions, and the carbon embodied in backfill material could potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with a potential increase in the volume of backfill material required.

Decommissioning and site restoration: Similar to closure, emission of carbon dioxide from traffic and plant and any use of diesel generators to power plant for decommissioning and site restoration would contribute to climate change.

It is not anticipated that closure and post-closure activities would be particularly vulnerable to the effects of climate change other than potential flooding from increased frequency and magnitude of storms if the site was located within an area at risk of flooding or surface water run-off was not managed appropriately. Changes in weather patterns as climate changes (e.g. very cold winters and hotter drier summers) would probably not affect closure and post-closure activities.

Assumptions and uncertainties: Refer to Sustainability Theme 7A for traffic and transport assumptions. The surface site area and the scale of surface development is assumed to be the same for the different waste inventories.



9. Climate Change

A. Higher Strength Rock (cont)

It is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory and a similar level of decommissioning and site restoration would take place on the surface. Therefore there is not considered to be a significant difference in potential climate change effects between the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory.

At this stage no site has been selected and therefore the location of the site in relation to floodplains or flood sensitive areas is unknown.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 9A of the construction phase assessment.

B. Lower Strength Sedimentary Rock

The potential effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 9A. Higher Strength Rock).

However, the scale of any effects could differ when compared to the higher strength rock type. Estimated quantities of backfill material for the remaining underground facilities and roadways are unavailable at this stage. However, in the case of the lower strength sedimentary rock, as the rock excavated from the construction of the underground facilities would not meet mass backfill requirements, backfill material would need to be imported to the site. In addition, it is noted that bentonite, which would be required for mass backfilling is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any carbon emissions. There is therefore a possibility that transport related carbon emissions associated with the import of mass backfill material could be greater for the lower strength sedimentary rock type.

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for the higher strength rock (refer to 9A. Higher Strength Rock).

Similar to the higher strength rock type, it is assumed for the evaporite rock type that no crushed rock backfill material for backfilling the drift and shaft, and common services area would need to be imported to the site as excavated rock stored on site would meet crushed rock backfill requirements for these areas, the transport of which could otherwise result in carbon emissions. It is unknown whether crushed rock requirements for mass backfilling the remaining underground roadways and facilities could be met using surplus excavated rock, as estimate quantities of mass backfill material required are not available at this stage.

Headline Issues

- CO₂ emissions during closure and post-closure due to the direct or indirect combustion of fossil fuel associated with traffic, plant, diesel generators and embodied energy within materials used.

For all of the host rock types, the effect of backfilling, sealing and closure of the Derived Inventory Upper Inventory in relation to transport related carbon emissions, and the carbon embodied in backfill material could potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility, with a potential increase in the volume of backfill material required.

As noted in Sustainability Theme 7A, based on current known backfill estimates transport related carbon emissions could be much greater for the lower strength sedimentary rock type when compared to the higher strength and evaporite rock types, due to the requirement to import all mass backfill material. In addition, for the lower strength sedimentary rock type it is noted that bentonite would need to be imported for the backfilling of the HLW/SF disposal tunnels. Bentonite is not widely available in the UK and therefore may need to be shipped from abroad, which would increase any carbon emissions.

It should be noted that estimate quantities of backfill material required for the remaining underground roadways and facilities are not available at this stage. For the higher strength and evaporite rock types, it is unknown whether crushed rock backfill requirements for backfilling the remaining underground roadways and facilities could be met using surplus excavated rock from the construction of the underground facility. However, surplus excavated rock would remain on site in surface bunds and therefore there could be the potential that some or all of the excavated rock could be used for this purpose.



10. Noise and Vibration

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: Several activities during backfilling, sealing and closure would be sources of potential noise nuisance and disturbance. Sources of on site noise include earth moving equipment and rock crushing facilities associated with backfilling, and traffic. However, the majority of the backfilling activities would be undertaken at depth, with negligible surface noise disturbance. Activities such as backfilling and HGV movements may also have vibration effects. However, any vibrations are expected to be of low amplitude and short in duration.

Decommissioning and site restoration: Similar to closure, perceptible noise would also be anticipated during decommissioning and site restoration. Sources of on site noise during decommissioning and site restoration include equipment and plant used for decommissioning activities, the demolition of surface facilities and infrastructure and traffic. Demolition activities and HGV movements may also have vibration effects. However, any vibrations would probably be of low amplitude and short in duration.

Depending on the proximity of sensitive receptors to the site, there would be the potential for noise and vibration to have an effect on sensitive receptors (occupants of residential buildings, community and recreational facilities and noise sensitive businesses and enterprises). However, whilst activities on site would generate noise and vibration, any effects from on site noise would probably not be significant due to the need to adhere to the requirements of legislation (Control of Pollution Act, 1974) and best practice set out in British Standard 5228: 2009 (Code of Practice for Noise and Vibration Control on Construction and Open Sites). Good management of any works would ensure that a breach of limits would be unlikely. Any noise and vibration generated during the closure and post-closure would also probably be less than during the construction and operational phases. However, HGV movements along the local road network may cause a local noise nuisance.

There would probably not be any difference in noise and vibration effects between the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory, due to the need to adhere to the requirements of legislation.

Assumptions and uncertainties: The scale of surface development is assumed to be the same for the different waste inventories. It is assumed that all backfill material and any construction waste would be transported to and from the site via road. It is also assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the site and may pass close to sensitive receptors such as residential areas.

At this stage, no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the site and works to sensitive receptors and the level and extent of noise and vibrations generated.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 10A of the construction phase assessment.

Summary of information requirements: Further information on the proposed closure and post-closure activities, including information on working hours, the likely areas of working and the noise levels of equipment to be used, is required to enable a more detailed and accurate assessment of the effects to be made.

B. Lower Strength Sedimentary Rock

The potential noise and vibration effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer 10A. Higher Strength Rock).

No effects in addition to those identified for higher strength rock are anticipated.

C. Evaporite Rock

The potential noise and vibration effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer 10A. Higher Strength Rock).

No effects in addition to those identified for higher strength rock are anticipated.



10. Noise and Vibration

Headline Issues

?	<ul style="list-style-type: none"> - Potential for noise disturbance and/or vibration effects from closure and post-closure activities (e.g. from earth moving equipment, demolition of surface facilities and vehicle movements). <p>There would probably not be any difference in noise and vibration effects between the different waste inventories and the different host rock types, due to the need to adhere to the requirements of legislation.</p> <p>At this stage, no site has been selected and subsequently the effect is uncertain. The potential for effects would depend on the proximity of the site and works to sensitive receptors and the level and extent of noise and vibrations generated.</p>
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11. Land Use

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: During the closure phase the remaining underground roadways, facilities, shafts and drift would be backfilled, sealed and closed. For the duration of these works the site would remain fenced off and inaccessible to the public, and therefore any land use effects associated with the presence of a GDF would remain. It is assumed that closure activities would take place within the surface site area (assumed to be approximately 1.1km² (including surface facilities and infrastructure and up to 3,589,000m³ of excavated rock stored in bunds).

Decommissioning and site restoration: Following closure, the surface facilities and infrastructure would be decommissioned and the site then restored to as near its preconstruction condition as practicable. Until site restoration was complete the site would remain fenced off, and therefore any land use effects associated with the presence of a GDF would remain.

Once completed, the effect and significance of site restoration would depend on site restoration and surrounding land uses. The effect would be positive where the land can be re-used for either its previous purpose (or another as appropriate), provided the land use pattern has not been affected in the long-term (i.e. there has been no change in land use surrounding the site that would affect land use within the site).

The NDA (or its successor organisation) in consultation with the local community could specify the end state for the site (including the preferred land use) which would then determine site restoration. If the site remained unfenced or could not be re-used, the effects on land use identified in the construction and operation phases would be extended to become longer term or permanent. The only structures that are anticipated to remain on site would be the surface bunds; therefore any land use effects associated with the presence of these bunds would remain.

Assumptions and uncertainties: It is assumed for the purposes of this assessment that the site would be greenfield. As such, depending on the grade of the agricultural land, it is assumed that good quality agricultural land (grades 1-3a) could be affected by the development. The surface site area is assumed to be the same for the different waste inventories. The only structures assumed to remain after site restoration is any surface bunds within the site. It is assumed for the purposes of this assessment that the entire area of surface land take would be fenced off and inaccessible throughout the closure and post-closure phase, until the site was fully restored, and that no further land take would be required.

It is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that for the Derived Inventory Upper Inventory and therefore there would be no significant difference in potential effects on land uses between the different waste inventories.

The effect on land use following completion is uncertain, as it is not known whether the site could be used for another purpose.

Proposed Mitigation/Enhancements: Given the timescale that would have passed since the construction of a GDF, the restoration of the site to its previous state may be inappropriate. Therefore, careful consideration should be given to the potential restoration at the time of closure, with input from local stakeholders.

Summary of information requirements: Given the period of time that would have lapsed substantial changes in surrounding land use may have taken place. Existing land use patterns would therefore need to be considered to inform the identification of a suitable restoration programme.



11. Land Use

B. Lower Strength Sedimentary Rock

Similar to the higher strength rock type, the surface site area for the lower strength sedimentary rock type is assumed to be approximately 1.1km², including surface facilities and infrastructure and up to 3,589,000m³ of excavated rock in bunds.

The potential land use effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer 11A. Higher Strength Rock).

No effects in addition to those identified for higher strength rock are anticipated.

C. Evaporite Rock

The potential land use effects that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer 11A. Higher Strength Rock).

However, for the evaporite rock type, the scale of any residual effect could differ when compared to the other host rock types. Similar to the other host rock types, the surface site area for the evaporite rock type would be approximately 1.1km², including surface facilities and infrastructure and surface screening bunds. However, in the case of the evaporite rock type none of the excavated rock would be stored in surface bunds. Instead the only excavated rock to be retained on site would be that required for backfilling, kept in a dedicated storage area. Although any surface screening bunds are anticipated to remain following site closure, it is anticipated that the dedicated storage area would be demolished as part of decommissioning, and therefore a greater area of the surface site area could be restored for future use.

Headline Issues

- Potential for site restoration works to have an effect on land uses (positive or negative), depending on the nature of the site restorations and the surrounding land uses.

For all of the host rock types there would probably not be any significant difference in effects between the different waste inventories, as the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that of the Derived Inventory Upper Inventory.

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- Similarly, there would probably not be any significant difference in effects associated with backfilling, sealing and closure and the decommissioning of the surface facilities and infrastructure between the different host rock types, as a similar level of activity would take place on the surface. However, following decommissioning and site restoration, the scale of any residual effect could differ between the different host rock types. Assuming that the dedicated storage area for excavated rock would be demolished as part of decommissioning for the evaporite rock type, a greater area of the surface site area could be restored for future use, as only the surface screening bunds would remain on site. These could be of a smaller volume than the surface bunds for the higher strength and lower strength sedimentary rock types, which are assumed to comprise up to 3,589,000m³ of excavated rock.

12. Socio-economics

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: Similar to the construction and operation phases, a range of specialist contractors and staff would be employed for the closure phase. During backfilling, sealing and closure, staff with similar skills to those used during construction and operation would be required. A proportion of jobs, particularly support jobs (e.g. plant operators, crane drivers and security staff) may be immediately suitable for the local workforce, creating opportunities for the employment of local contractors and individuals.

As per the construction and operational phases, any site based staff and visiting contractors could continue to have a positive effect on local economy through increased visitor spend and demand for local accommodation and services. However, although activities would continue to generate employment with associated effects on the local economy, the scale of employment would be much lower than that during the operational phase, with the potential for job losses of operational staff where they are no longer required.



12. Socio-economics

A. Higher Strength Rocks (cont)

During closure of the underground facilities significant quantities of materials would be required for mass backfilling. As per the previous phases, due to the materials requirement the closure of the underground facility could continue to affect the supply chains of other industries. However, any effects on markets and demand would reduce as closure progresses.

Depending on the location and the proximity of local populations, there may be a negative effect on quality of life from closure activities (e.g. associated with traffic on the road network, noise and air quality effects from works and traffic), although it is deemed to be uncertain until the location of a GDF is identified. Potential receptors include neighbouring residents, schools and users of community, leisure and recreational facilities, public open space and rights of way. However, the works would be of a similar, or lesser, scale and nature as that of the proposed operational activities and there would not be any increase in effects. Any effects on quality of life would reduce as closure progresses.

Decommissioning and site restoration: Similar to the closure phase, decommissioning and site restoration staff with similar skills to those used during construction and operation would be required, which could generate a proportion of jobs immediately suitable for the local workforce. However, again the scale of employment would be much lower than that during the operational phase, with the potential for job losses of both operational staff and closure staff where they are no longer required. Employment would probably continue to decrease as decommissioning progresses and therefore plans would need to be put in place to retain staff or help them find alternative employment.

The NDA estimate that, on average 379 people per year could be employed during the closure and post-closure phase, for both the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory. This would be a reduction of 249 people per year estimated to be employed during the operational phase.

Following completion of the site restoration the majority of staff employed at a GDF, with the exception of those professional staff involved in post site restoration maintenance, would no longer be employed. This could have a significant negative effect on employment in the local area with significant effects on the local economy.

At this stage it is uncertain whether the presence of the underground facility would affect the desirability of the surrounding area as a place to live, work and visit. This would depend on people's perceptions of the underground facility at the time, for example their views on the long-term safety of the facility.

The closure and post-closure phase for the Derived Inventory Upper Inventory would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility. The potential effect of the Derived Inventory Upper Inventory could therefore be greater than that of the Derived Inventory Reference Case excluding Pu/U.

Assumptions and uncertainties: The scale of surface development is assumed to be the same for the different waste inventories, as the maximum rate of waste package delivery would not increase. It is assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the site and may pass close to sensitive receptors such as residential areas. It is assumed that the level of employment would be the same of the different waste inventories, as the scale of works would not increase on an annual basis, instead the operational period would be longer.

The potential socio-economic effects of a GDF are largely dependent on the proximity of local populations to the site, the relationship with the upstream and downstream supply chains, the nature of the local economy and the sensitivity to the character of the effects predicted. However, the closure of such a significant facility would have a detrimental effect on the local economy.

Proposed Mitigation/Enhancements:

A community benefits package agreed at the beginning of the project would continue to provide socio-economic benefits beyond the closure of the facility for future generations (such as improved transport links which may help improve access to employment opportunities elsewhere).

There would be a commitment by the NDA to provide long-term transferable skills programmes which would help to reduce the effects of the facility's closure by ensuring adequate training to ensure relevant skills can be transferred to other industries or projects. In particular, there may be a need for future radioactive waste disposal following future nuclear programmes.



12. Socio-economics

B. Lower Strength Sedimentary Rock

The potential effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer 12A. Higher Strength Rock).

No effects in addition to those identified for higher strength rock are anticipated.

C. Evaporite Rock

The potential effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer 11A. Higher Strength Rock).

No effects in addition to those identified for higher strength rock are anticipated.

Headline Issues

+	<ul style="list-style-type: none"> - Potential for a proportion of jobs to be suitable for the local workforce, creating opportunities for the employment of local contractors and individuals. <p>However, following completion of the site restoration, the majority of staff employed at a GDF, with the exception of those professional staff involved in post site restoration maintenance would no longer be employed. This could have a significant negative effect on employment in the local area, with significant effects on the local economy.</p>
?	<ul style="list-style-type: none"> - Potential for the requirement for significant quantities of mass backfill material to have an effect on supply chains and local prices although this depends on the availability of resources and the demand at the point of excavation. - Potential for closure and post-closure activities to have an effect on the quality of life of populations (e.g. traffic on the road network, noise and air quality effects). - Potential for a GDF to have an effect on the desirability of the surrounding area as a place to live, work and invest. <p>Due to the requirement to import significant volumes of mass backfill material, there is the potential for the lower strength sedimentary rock type to have a greater effect on supply chains. The higher strength rock and evaporite rock types present greater opportunities for excavated rock use on site, reducing the effect of these types on supply.</p> <p>At this stage, no site has been selected and subsequently the potential for effects on quality of life and desirability is uncertain. The potential for effects would depend on the proximity of the site and construction works to sensitive receptors and the level and extent of any disturbance.</p> <p>For all of the host rock types, construction for the Derived Inventory Upper Inventory GDF would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility. The potential effect of the Derived Inventory Upper Inventory could therefore be greater than that of the Derived Inventory Reference Case excluding Pu/U.</p>

13. Health and Well-being

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: There would be the potential for closure activities to have a negative effect on health and well being (e.g. disturbance from noise and vibrations, and air quality effects from works and traffic). Potential receptors include on site staff and visitors, neighbouring residents, schools and users of community, leisure and recreational facilities, open space and rights of way. However, the works would be of a similar, or lesser, scale and nature as that of the proposed operational activities and any effects on health and well-being would reduce as closure progresses. The majority of the activities would also be undertaken at depth.



13. Health and Well-being

A. Higher Strength Rock (cont)

Decommissioning and site restoration: Similar to the closure phase, decommissioning of the surface infrastructure and facilities and site restoration could have a negative effect on health and well being. The effect from decommissioning and site restoration could potentially be greater than that of backfilling, sealing and closure, as all activities would be taking place on the surface.

In the long-term, there could be concerns regarding health and safety associated with the presence of radioactive waste in the underground facility. There would be the potential for the perceived risks associated with the presence of the underground facility to cause concern, which could affect people's health and well-being (e.g. increased/elevated stress levels). Consideration of radiological effects is outside the scope of this assessment. However, the facility would be designed to meet regulatory requirements with regard to the protection of the environment and the public from radiological hazards.

Closure and post-closure activities for the Derived Inventory Upper Inventory would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility. The potential effects of the Derived Inventory Upper Inventory on health and well-being could therefore be greater than that of the Derived Inventory Reference Case excluding Pu/U.

There may be some beneficial effects on well-being due to the continued implementation of a community benefits package.

Assumptions and uncertainties: It is assumed that all backfill material and any waste associated with closure and post-closure would be transported to and from the site via road. It is also assumed that traffic may have to use local roads (e.g. lower order, B and C roads) to reach the sites and may pass close to sensitive receptors such as residential areas.

At this stage no site has been selected and subsequently the potential effects on health and well being are uncertain. The potential for effects on health and well-being depends on the location of the site and its proximity to sensitive receptors (e.g. residents).

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 13A of the construction phase assessment.

Summary of information requirements: Further information is required on the proximity of the site to sensitive receptors, and the proposed closure and post-closure activities within the site, to identify the likely effects in more detail.

B. Lower Strength Sedimentary Rock

The potential health and well-being effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 13A. Higher Strength Rock). No effects in addition to those identified for higher strength rock are anticipated.

C. Evaporite Rock

The potential health and well-being effects that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 13A. Higher Strength Rock). No effects in addition to those identified for higher strength rock are anticipated.

Headline Issues

- Potential for closure and post-closure activities to have a negative effect on health and well-being.
- Potential for perceived risks associated with a GDF to cause concern.

?

For all of the host rock types, closure and post-closure activities for the Derived Inventory Upper Inventory would continue over a longer time period to that of the Derived Inventory Reference Case excluding Pu/U due to the increased size of the underground facility. The potential effect of the Derived Inventory Upper Inventory on health and well-being could therefore be greater than that of the Derived Inventory Reference Case excluding Pu/U. The scale of the closure and post-closure activities taking place would not differ between the different host rock types and therefore there would not be any significant difference in potential effects.

At this stage no site has been selected and subsequently the potential for effects on health and well-being is uncertain. This depends on the proximity of the site to sensitive receptors and the extent of any disturbance.



14. Safety

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: Closure activities, particularly backfilling, would pose a number of significant hazards to the on site workforce and visitors to the site. Potential major hazards include: collision and impact hazards (e.g. involving plant, vehicles and personnel); exposure to substances hazardous to health (e.g. contact with cement, dusts etc); entrapment, asphyxiation, and loss of ventilation (e.g. associated with underground works); electrical hazards (e.g. electrical shock from live cables); and other occupational hazards such as working at height and manual handling.

Decommissioning and site restoration: Similar to closure, decommissioning and site restoration activities could also present a hazard, including collision and impact hazards; exposure to substances hazardous to health; electrical hazards; and other occupational hazards such as working at height and manual handling.

However, although there would be many potential risks during closure and post-closure, it is assumed that any risk would have been identified and managed through the contractor(s)/operator(s) compliance with health and safety legislation and risk management procedures.

Closure and post-closure activities would probably not present a significant risk to the public (i.e. local communities) provided access to the site was restricted and the relevant health and safety procedures were in place. Although traffic movements on the local road network could potentially increase the risk of road traffic accidents.

A GDF and associated transport infrastructure would be designed to meet regulatory requirements with regard to the protection of the environment and public from radiological hazards. The level of protection would be consistent with the national standard at the time of waste disposal.

It is assumed that closure and post-closure activities for the Derived Inventory Reference Case excluding Pu/U would be similar in scale to the Derived Inventory Upper Inventory, as health and safety regulations govern the level of activity on site and thus the scale of the work is not expected to increase, instead the period would be longer. Therefore there would probably not be a significant difference in potential safety effects between the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory. However, the length of time involved may increase the statistical change of accidents occurring.

Assumptions and uncertainties: It is assumed that the staff undertaking the works would not be subjected to any higher degree of risk than if they undertook such activities elsewhere as they would be professionally trained, operate under safe systems of work and should understand the risks of the activities which they practice. A GDF would be licensed under the Nuclear Installations Act 1965, which infers a high degree of control in accordance with the nuclear site licence.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 14A of the construction phase assessment.

Summary of information requirements: Further information is required on the proximity of the site to sensitive receptors, and the proposed operational activities, to identify the likely effects in more detail. In particular, the exposure of sensitive receptors to hazards associated with normal activities as well as accident and emergency situations should be considered.

B. Lower Strength Sedimentary Rock

The potential effects and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 14A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.

C. Evaporite Rock

The potential effects and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 14A. Higher Strength Rock).

No effects in addition to those identified for the higher strength rock type are anticipated.



14. Safety

Headline Issues

- Risk to human health and safety from closure and post-closure activities.
- Potential for an increased risk of road traffic accidents associated with any increase in traffic movements.
- Taking account of health and safety regulations, it is assumed that the level of closure and post-closure activity taking place would not vary, and therefore there would probably not be a significant difference in potential safety effect between the different waste inventories and different host rock types. However, the length of time involved may increase the statistical change of accidents occurring.

15. Waste

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure: The key waste materials during backfilling, sealing and closure would be waste backfill material (crushed rock, bentonite and concrete in the case of the higher strength rock type). Secondary wastes would arise such as woods and metals, packaging and plastics. There would also be some general office waste arising such as paper, organic canteen waste and packaging.

The potential effect of the Derived Inventory Upper Inventory in relation to waste could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased GDF size, with a potential increase in the volume of backfill material required and subsequent waste generated.

Decommissioning and site restoration: The key waste arisings during decommissioning would be waste building materials from decommissioning and/or demolition of the surface buildings and infrastructure such as concrete, bricks/blocks, tiles, and woods and metals, and plastics. Other wastes could include packaging, nails/bolts, worn tools, canisters, drums (e.g. fuel, diesel, chemicals) and food waste and food packaging from on site food consumption.

Some of the waste may be treated as special or hazardous waste and would need to be handled in compliance with the relevant waste regulations.

There would also be some general office waste such as paper, organic canteen waste, packaging and possibly some electrical waste, e.g. computers/printers or other electrical products.

Assumptions and uncertainties: It is assumed that the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that for the Derived Inventory Upper Inventory and therefore there would not be any significant difference in waste arisings between the different waste inventories.

As a detailed scheme design has not been finalised, at this stage specific quantities of likely waste arisings and the extent of any re-use or recycling cannot be determined.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 15A of the construction phase assessment.

A demolition waste management plan should be developed to ensure that the demolition wastes are recycled or re-used so far as possible.

Summary of information requirements: Further information on the proposed scheme design, construction, backfill methods and decommissioning is required to enable a more detailed and accurate assessment of waste arisings to be made.

B. Lower Strength Sedimentary Rock

The types of waste arisings and mitigation/enhancements for the lower strength sedimentary rock type are considered to be the same as those identified for higher strength rock (refer to 15A. Higher Strength Rock). However, the scale of resource use would vary between the different host rock types. However, as specific quantities of waste arisings are unknown, the extent of any potential differences is unknown. In the case of the lower strength sedimentary rock type, waste buffer and backfill material would comprise bentonite and sand.



15. Waste

C. Evaporite Rock

The types of waste arisings and mitigation/enhancements for the evaporite rock type are considered to be the same as those identified for higher strength rock (refer to 15A. Higher Strength Rock).

However, the scale of resource use is expected to vary between the different host rock types. However, as specific quantities of waste arisings are unknown, the extent of any potential differences is unknown. In the case of the evaporite rock type, waste buffer and backfill material would comprise crushed rock salt and Magnesium Oxide (MgO) sacks.

Headline Issues

- Waste arisings from closure and post-closure activities, including some potentially hazardous or special waste.

For all host rock types for the backfilling, sealing and closure stage, the potential effect of the Derived Inventory Upper Inventory in relation to waste could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased GDF size, with a potential increase in the volume of backfill material required and subsequent waste generated. There would not be any significant difference in waste arisings between the Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory during decommissioning and site restoration, as the scale of surface development is assumed to be of the same scale.

The extent of waste arisings would vary between the different host rock types. However, as specific quantities of backfill material and waste arisings are unknown, the extent of any potential differences is unknown.

16. Resource Use, Utilities and Services

A. Higher Strength Rock

Assessment of Effects:

Backfilling, sealing and closure:

For the higher strength rock type, the greatest level of resource use during closure would probably be associated with the sealing, backfilling and closure of the underground facility, which would require significant quantities of mass backfill material.

It is estimated that approximately 263,771m³ of crushed rock would be required for backfilling the underground access tunnels (drift and shafts), and 296,308m³ of crushed rock would be required for backfilling the common services area for both the higher strength rock Derived Inventory Reference Case excluding Pu/U and Derived Inventory Upper Inventory. In the case of the higher strength rock, rock excavated during the construction of the underground facility would meet crushed rock mass backfilling requirements for these areas, reducing the need to import crushed rock from elsewhere for the backfilling of these areas. It is unknown whether crushed rock backfill requirements for mass backfilling the remaining underground roadways and facilities could met using surplus excavated rock from the construction of the underground facility, as estimated quantities of mass backfill material required for the remaining underground roadways and facilities are not available at this stage.

Key utilities and services that would be required during closure include electricity, water supplies, communications systems, and ventilation systems for works underground. However, the level of utilities and services use during closure would probably be less than that during construction and operation.

Throughout closure there would be energy use associated with the operation of plant machinery and equipment, site buildings and infrastructure (heating, lighting, canteen facilities, electronics etc), the operation of ventilation systems to ensure a supply of clean air, and lighting to allow safe working and for security purposes. Diesel generators may be used as the primary source of electricity if suitable means of connection do not exist, or the local mains supply is deemed unreliable.

Water would be required throughout closure for routine processes such as wash-down and decontamination; and for domestic purposes such as drinking water, canteen use and toilet and washing facilities. In addition, a reliable and adequate water storage and distribution system would be required for fire fighting (refer to Sustainability Theme 5A). Sewerage systems for treatment of wastewater may also be required, depending on whether there would be opportunity to connect to the existing network.



16. Resource Use, Utilities and Services

A. Higher Strength Rock (cont)

The significance of effects is dependent to some extent on the location of the site, which would in turn dictate the availability of resources, utilities and services, and the sourcing of specific mass backfill materials and their transport distance. Notwithstanding this, the potential effect of backfilling, sealing and closure of the Derived Inventory Upper Inventory could be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased GDF size, with an associated increase in resource use (particularly mass backfill materials).

Decommissioning and site restoration: Similar to closure, key utilities and services would be required during decommissioning, although utilities and services use would decrease as decommissioning and site restoration activities progress.

Assumptions and uncertainties: It is assumed that the surface site area and the scale of surface development for the Derived Inventory Reference Case excluding Pu/U would be the same as that for the Derived Inventory Upper Inventory and a similar level of decommissioning and site restoration would take place on the surface. Therefore there would not be a significant difference in potential effects between the Derived Inventory Reference Case excluding Pu/U and the Derived Inventory Upper Inventory associated with decommissioning of the site surface facilities.

At this stage no site has been selected, a detailed scheme design has not been finalised and limited information is available on the proposed backfill, decommissioning and site restoration methods. Therefore, specific quantities of resources required, the availability of resources and the sourcing of specific materials cannot be determined.

Proposed Mitigation/Enhancements: Refer to the proposed mitigation measures and enhancements in Sustainability Theme 16A of the construction phase assessment.

Opportunities for the beneficial re-use of any surplus excavated rock remaining on site should be explored. For example, excavated rock could be exported via railhead for use as aggregates/construction materials. The transport implications of exporting excavated rock off-site would need to be considered carefully. The available options should be subject to environmental assessment.

Summary of information requirements: Further information on the proposed scheme design, construction, backfill methods and decommissioning is required to enable a more detailed and accurate assessment of resource use to be made. Information on potential resource markets and demand is required to inform the assessment of effects. Site-specific information is required to determine the existing availability of utilities and services.

B. Lower Strength Sedimentary Rock

The potential effects that could occur for the lower strength sedimentary rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 16A. Higher Strength Rock).

However, the scale of resource use would vary between the different host rock types. It is estimated that approximately 126,660m³ of mass backfill material (bentonite and sand in a 30:70 mix) would be required for backfilling the underground access tunnels (drift and shafts), and 73,749m³ of mass backfill material would be required for backfilling the common services area. In the case of the lower strength sedimentary rock type, none of the excavated rock would meet backfill requirements, and as a result all backfill material would need to be imported. It is noted that bentonite is not widely available in the UK and therefore may need to be shipped from abroad.

C. Evaporite Rock

The potential effects that could occur for the evaporite rock type and the potential mitigation/enhancements are considered to be the same as those identified for higher strength rock (refer to 16A. Higher Strength Rock).

However, the scale of resource use would vary between the different host rock types. It is estimated that approximately 191,314m³ of crushed rock salt would be required for backfilling the underground access tunnels (shafts), and 108,807m³ of crushed rock salt would be required for backfilling the common services area. Similar to the higher strength rock type, in the case of evaporite rock, rock excavated during the construction of the underground facility would meet crushed rock salt mass backfilling requirements for these areas, reducing the need to import crushed rock salt from elsewhere for the backfilling of these areas. It is unknown whether crushed rock backfill requirements for mass backfilling the remaining underground roadways and facilities could met using surplus excavated rock from the construction of the underground facility, as estimated quantities of mass backfill material required for the remaining underground roadways and facilities are not available at this stage.



16. Resource Use, Utilities and Services

Headline Issues

- Requirement for significant quantities of mass backfill material.
- Increase in resource use, utilities and services throughout the closure and post-closure phase.

For all of the host rock types, the potential effect of the Derived Inventory Upper Inventory could potentially be greater than that of the Derived Inventory Reference Case excluding Pu/U due to the increased GDF size, with an associated increase in resource use (particularly backfill materials).

Although the types of resources, utilities and services would be similar for the different host rock types, the extent of resource use would vary between the different host rock types. Estimates of the quantities of mass backfill materials required for the backfilling of the remaining underground roadways and facilities are not currently available. Notwithstanding this, for both the higher strength and evaporite rock types, excavated rock from the construction of the underground facilities could meet crushed rock access tunnel (drift and/or shafts) and common services area backfilling requirements, which would negate the need to import any crushed rock for backfilling of these areas. For the higher strength and evaporite rock types, it is unknown whether crushed rock backfill requirements for backfilling the remaining underground roadways and facilities could be met using surplus excavated rock from the construction of the underground facility. However, surplus excavated rock would remain on site in surface bunds and therefore there could be the potential that some or all of the excavated rock could be used for this purpose. In the case of the lower strength sedimentary rock, the excavated rock would not meet backfill requirements and consequently none of the excavated rock would be used for backfilling. Therefore all backfill material would need to be imported to the site. Mass backfill material resource requirements could therefore potentially be greater for the lower strength sedimentary rock type when compared to the higher strength and evaporite rock types. It is noted that bentonite is not widely available in the UK and therefore bentonite may need to be shipped from abroad.

