Radioactive Waste Management

NDA Report no. DSSC/331/01

Geological Disposal

Generic Environmental Assessment

December 2016

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Preface

Radioactive Waste Management Limited (RWM) has been established as the delivery organisation responsible for the implementation of a safe, sustainable and publicly acceptable programme for the geological disposal of the higher activity radioactive wastes in the UK. As a pioneer of nuclear technology, the UK has accumulated a legacy of higher activity wastes and material from electricity generation, defence activities and other industrial, medical and research activities. Most of this radioactive waste has already arisen and is being stored on an interim basis at nuclear sites across the UK. More will arise in the future from the continued operation and decommissioning of existing facilities and the operation and subsequent decommissioning of future nuclear power stations.

Geological disposal is the UK Government's policy for higher activity radioactive wastes. The principle of geological disposal is to isolate these wastes deep underground inside a suitable rock formation, to ensure that no harmful quantities of radioactivity will reach the surface environment. To achieve this, the wastes will be placed in an engineered underground facility – a geological disposal facility (GDF). The facility design will be based on a multi-barrier concept where natural and man-made barriers work together to isolate and contain the radioactive wastes.

To identify potentially suitable sites where the GDF could be located, the Government has developed a consent-based approach, based on working with interested communities that are willing to participate in the siting process. The siting process is on-going and no site has yet been identified for the GDF.

Prior to site identification, RWM is undertaking preparatory studies which consider a number of generic geological host environments and a range of illustrative disposal concepts. As part of this work, RWM maintains a generic Disposal System Safety Case (DSSC). The generic DSSC is an integrated suite of documents which together give confidence that geological disposal can be implemented safely in the UK.

Executive Summary

UK Government policy for the long term management of higher activity waste is 'geological disposal', a solution to radioactive waste management that will be safe in the long term without dependence on ongoing human intervention.

The process of siting and constructing a geological disposal facility (GDF) is likely to take several decades and, once the facility is operational, it is likely to operate for more than a century. At the end of this period, the facility will be closed and all the radioactive waste will remain sealed hundreds of metres below ground with no harmful quantities of radioactivity ever returning to the surface.

To identify potential sites where the GDF can be located, the UK Government and devolved administrations favour a consent-based approach based on working with communities that are willing to participate in the siting process. The site selection process has not yet been undertaken and so this report considers generically the implementation of the GDF within England, Wales or Northern Ireland. Scotland is not included as it is Scottish Government policy that the long-term management of higher activity waste should be in near-surface facilities located as near to the site where the waste is produced as possible.

This assessment sets out the non-radiological environmental effects of geological disposal; in so far as they can be assessed at a generic level (the assessment is not location-specific). Radiological effects on the environment are covered in RWM's generic Environmental Safety Case. The Generic Environmental Assessment updates a previous assessment undertaken in 2014 to take account of:

- recent changes to the radioactive waste inventory for disposal
- RWM's latest generic design work and implementation plans for the disposal system
- Government policy as set out in the 2014 White Paper: Implementing Geological Disposal – A Framework for the long-term management of higher activity radioactive waste

The objectives of the assessment are to:

- support the generic design process for the GDF by feeding in potential mitigation[1] measures, where appropriate
- support the early stages of the siting process for the GDF
- inform potential host communities of potential environmental effects
- support engagement with stakeholders

Effects have been considered for each phase of the life cycle of the GDF, which can be summarised as:

- siting process, including intrusive, surface based investigation (boreholes)
- initial construction prior to waste emplacement, including underground based investigation
- operation (waste emplacement), including ongoing construction of additional disposal areas as they are required
- closure

[1] 'Mitigation' in this sense is anything which avoids, reduces, remedies or compensates for an adverse effect.

In this generic assessment it has not been possible to determine in detail the likely extent and nature of environmental effects as they will be dependent on the location of the GDF, the characteristics of the local environment and host community, and detailed design and mitigation proposals. However, a range of potential environmental effects, both beneficial and adverse has been identified, along with a series of generic mitigation, monitoring and enhancement measures that could be adopted. More detailed, location-specific assessment work will be carried out during the siting process.

The potential health and socio-economic effects of the GDF are covered in parallel assessments. However, any links to associated environment effects are considered in this assessment where relevant.

The potential effects that the development of the GDF can have on the environment have been assessed in this report across 12 themes, as follows:

- landscape and visual amenity
- cultural heritage
- geology and soils
- the water environment
- biodiversity, flora and fauna
- traffic and transport
- air quality
- climate change
- noise and vibration
- land use and community
- waste
- resource use, utilities and services

Effects have been considered in relation to identified objectives for each theme. Overall, across these 12 themes, a wide range of potential environmental effects has been identified. In some cases, the extent and significance of these effects will vary with the geological environment and the other characteristics of the site chosen for the GDF. It should be noted that this generic assessment focuses largely on the unmitigated effects of the GDF, as most mitigation proposals will be developed on a site-specific basis. Effective mitigation measures are likely to be available to address many potential negative effects – enabling them to be avoided or reduced. In many cases it is possible that environmental benefits could be realised, depending on local circumstances, for instance through landscape enhancement works, new wildlife habitat creation or enhancements for cultural heritage sites. Therefore, with site-specific mitigation and enhancement in place, adverse effects may be lower than assessed in this report and some beneficial effects are likely.

Key conclusions arising from the Generic Environmental Assessment are set out below.

Environmental effects

Those themes under which significant environmental effects are thought most likely are landscape (including townscape) and visual amenity; and waste. The surface facilities are likely to affect the character of the local landscape and local views. Excavation of the underground facilities will generate significant volumes of rock spoil. In addition, there is some potential for significant air quality effects related to transport movements, depending on the balance between road and rail transport in the final proposals for the GDF and on site-specific factors (such as the nature of the local road network and the details of the

mitigation/enhancement measures proposed). There is also some potential for significant effects in relation to climate change and land use.

Potential negative effects have also been identified under other themes (geology and soils; water; resource use, utilities and services). It is likely that such effects could be effectively mitigated through well-established control measures and that, in some cases, opportunities will be available to provide related benefits.

For three themes – cultural heritage; biodiversity; and noise and vibration – potential effects were considered too dependent on site-specific information to enable a credible assessment at this generic stage. There are potential negative effects under these themes that may arise from development of the GDF, but at this generic stage the likelihood that an effect will occur and its potential significance cannot be predicted.

For each theme, consideration has been given to the potential for mitigation and enhancement. At this stage, generic measures have been identified that will contribute towards meeting the environmental objectives. In some cases, positive effects are likely with such measures in place.

Life cycle of the GDF

Potentially significant effects will be associated primarily with the initial construction phase, with some potential for such effects to continue (under some themes) into the operational phase.

The scale of works proposed during the siting process is much smaller and such works will be temporary and relatively short term, such that no significant effects have been identified.

Compared to construction and operation, the scale of activity is likely to be reduced in the closure phase. No new significant effects have been identified during this phase.

Host rock types

For the majority of the themes, the evidence available from the assessment does not permit a clear conclusion as to whether the nature of the host rock will have a significant influence on the nature of environmental effects, as much is dependent on the location of the GDF as well as the rock type.

However, it is noted that the principal influence on the amount of excavated rock spoil that may have to be removed from the site and the amount of material that may have to be brought to the site for backfilling is the total excavated volume of the GDF. Estimates suggest that the overall volume of rock to be excavated will be greatest for a higher strength rock site and least for an evaporite rock site.

In principle, the illustrative designs for the GDF aim to maximise the retention of excavated material on-site in the form of temporary or permanent screening / storage mounds around the surface facilities. The ability to store rock on site would minimise the amount of material to be exported from the site, while re-use of stored rock from excavations during the backfilling process would minimise the amount of material to be brought to the site for this purpose.

For the evaporite rock design, only excavated material arising from initial site clearance and construction of surface facilities (and possibly shaft construction) is likely to be suitable for storage on site. Most of the spoil arising from underground construction is assumed to be unsuitable for the construction of mounds, due to its solubility and the potential environmental effects of saline leachate. Such spoil would have to be transported off-site.

These differences in rock type will influence the nature and scale of effects under some environmental themes, notably transport, but also landscape, climate change, waste and resource use.

Key sources of potential effects

For environmental receptors located above ground in the vicinity of the GDF, the key sources of potential effects are anticipated to be the initial construction of the surface site and associated transport infrastructure, and spoil management associated with excavation of the underground facilities. It is the initial construction works that will cause the main effects on landscape / townscape, heritage, biodiversity, water and land use, whilst some effects under these themes are also expected to continue during the operational phase.

Underground construction, emplacement of waste and backfilling have potential effects in terms of transport (and associated environmental effects), climate change, waste (notably rock spoil) generation and resource requirements.

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1 Introduction

1.1 Introduction to the generic Disposal System Safety Case

RWM has been established as the delivery organisation responsible for the implementation of a safe, sustainable and publicly acceptable programme for geological disposal of the UK's higher activity radioactive waste. Information on the approach of the UK Government and devolved administrations of Wales and Northern Ireland[2] to implementing geological disposal, and RWM's role in the process, is included in an overview of the generic Disposal System Safety Case (the Overview) [1].

A geological disposal facility (GDF) will be a highly-engineered facility, located deep underground, where the waste will be isolated within a multi-barrier system of engineered and natural barriers designed to prevent the release of harmful quantities of radioactivity and non-radioactive contaminants to the surface environment. To identify potentially suitable sites where a GDF could be located, the Government is developing a consent-based approach based on working with interested communities that are willing to participate in the siting process [2]. Development of the siting process is ongoing and no site has yet been identified for a GDF.

In order to progress the programme for geological disposal while potential disposal sites are being sought, RWM has developed illustrative disposal concepts for three types of host rock. These host rocks are typical of those being considered in other countries, and have been chosen because they represent the range that may need to be addressed when developing a GDF in the UK. The host rocks considered are:

- higher strength rock, for example, granite
- lower strength sedimentary rock, for example, clay
- evaporite rock, for example, halite

The inventory for disposal in the GDF is defined in the Government White Paper on implementing geological disposal [2]. The inventory includes the higher activity radioactive wastes and nuclear materials that could, potentially, be declared as wastes in the future. For the purposes of developing disposal concepts, these wastes have been grouped as follows:

- High heat generating wastes (HHGW): that is, spent fuel from existing and future power stations and High Level Waste (HLW) from spent fuel reprocessing. High fissile activity wastes, that is, plutonium (Pu) and highly enriched uranium (HEU), are also included in this group. These have similar disposal requirements, even though they don't generate significant amounts of heat.
- Low heat generating wastes (LHGW): that is, Intermediate Level Waste (ILW) arising from the operation and decommissioning of reactors and other nuclear facilities, together with a small amount of Low Level Waste (LLW) unsuitable for near surface disposal, and stocks of depleted, natural and low-enriched uranium (DNLEU).

RWM has developed six illustrative disposal concepts, comprising separate concepts for HHGW and LHGW for each of the three host rock types. Designs and safety assessments for the GDF are based on these illustrative disposal concepts.

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[2] Hereafter, references to Government mean the UK Government including the devolved administrations of Wales and Northern Ireland. Scottish Government policy is that the long term management of higher activity radioactive waste should be in near-surface facilities and that these should be located as near as possible to the site where the waste is produced..

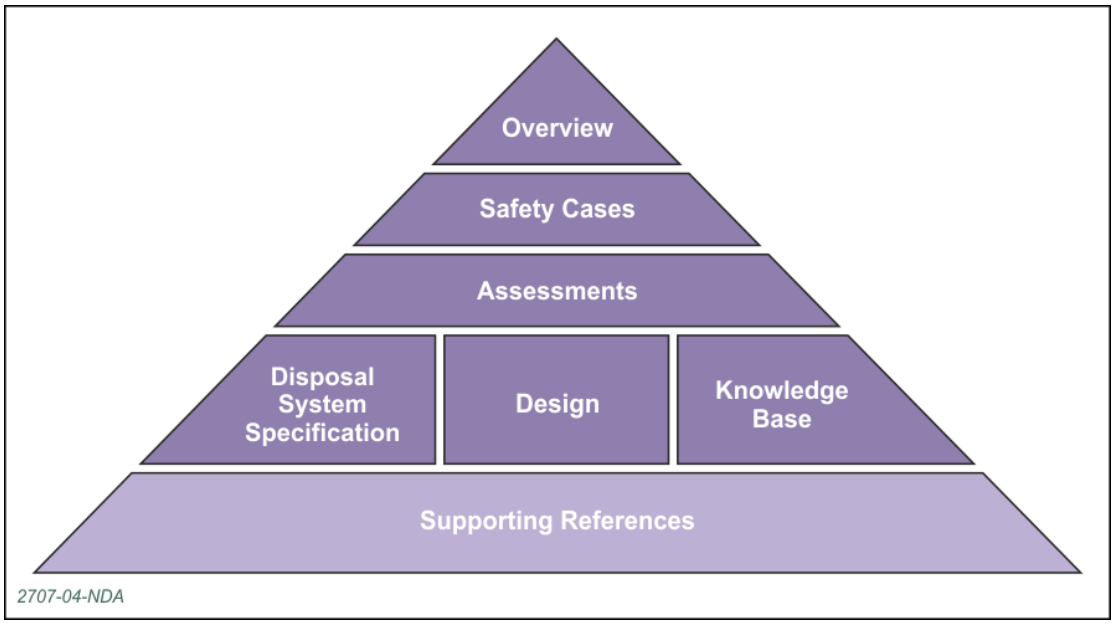
High level information on the inventory for disposal, the illustrative disposal concepts and other aspects of the disposal system is collated in a technical background document (the Technical Background) [3] that supports this generic Disposal System Safety Case.

The generic Disposal System Safety Case (DSSC) plays a key role in the iterative development of a geological disposal system. This iterative development process starts with the identification of the requirements for the disposal system, from which a disposal system specification is developed. Designs, based on the illustrative disposal concepts, are developed to meet these requirements, which are then assessed for safety and environmental impacts. An ongoing programme of research and development informs these activities. Conclusions from the safety and environmental assessments identify where further research is needed, and these advances in understanding feed back into the disposal system specification and facility designs.

The generic DSSC provides a demonstration that geological disposal can be implemented safely. The generic DSSC also forms a benchmark against which RWM provides advice to waste producers on the packaging of wastes for disposal.

Document types that make up the generic DSSC are shown in Figure 1. The Overview provides a point of entry to the suite of DSSC documents and presents an overview of the safety arguments that support geological disposal. The safety cases present the safety arguments for the transportation of radioactive wastes to the GDF, for the operation of the facility, and for long-term safety following facility closure. The assessments support the safety cases and also address non-radiological, health and socio-economic considerations. The disposal system specification, design and knowledge base provide the basis for these assessments. Underpinning these documents is an extensive set of supporting references. A full list of the documents that make up the generic DSSC, together with details of the flow of information between them, is given in the Overview.

Figure 1 Structure of the generic DSSC



1.2 Introduction to the Generic Environmental Assessment Report

This report is the Generic Environmental Assessment (GEA). It is new to the generic DSSC, but updates a Generic Environmental Assessment produced in 2014 [4]. This, in turn, built on a generic Environmental and Sustainability Assessment published in 2010, alongside the 2010 generic DSSC.

The generic DSSC was previously published in 2010. There are now a number of drivers for updating the safety case as an entire suite of documents, most notably the availability of an updated inventory for disposal [5].

1.3 Objective

The GEA sets out the non-radiological environmental effects of geological disposal; in so far as they can be assessed at a generic level (the assessment is not location-specific). Radiological effects on the environment are covered in RWM's generic Environmental Safety Case [6].

The Generic Environmental Assessment updates the previous assessment undertaken in 2014 to take account of:

- recent changes to the radioactive waste inventory for disposal
- RWM's latest generic design work and implementation plans for the disposal system
- Government policy as set out in the 2014 White Paper

The objectives of the assessment are to:

- support the generic design process for the GDF by feeding in potential mitigation measures, where appropriate
- support the early stages of the siting process for the GDF
- inform potential host communities of potential environmental effects
- support engagement with stakeholders

1.4 Scope

1.4.1 Technical scope

Potential effects on the environment have been assessed across 12 environmental themes:

- landscape and visual amenity
- cultural heritage
- geology and soils
- the water environment
- biodiversity, flora and fauna
- traffic and transport
- air quality
- climate change
- noise and vibration
- land use and community
- waste

- resource use, utilities and services

The health and socio-economic effects of geological disposal are covered in separate, parallel assessments and are therefore not duplicated within this report [7] [8]. Where relevant, cross references are made to these reports. The environmental effects of transport are considered in this report, supported by information provided in the Generic Transport System Design [9].

The preparation and packaging of radioactive waste for transport and disposal, at waste producing sites, is not covered, and neither is any activity associated with the UK Government and devolved administration's proposed programme of community investment as part of the site selection process.

The level of detail and certainty with which different aspects have been addressed is appropriate to the level of information that is available about those aspects of the project at the current generic stage.

1.4.2 Temporal scope

The GEA considers the effects of developing the GDF throughout its life cycle including:

- the selection of a site for the GDF, including any intrusive, surface based investigations
- the initial period of construction activity, prior to waste emplacement
- the ongoing period of operation (and concurrent ongoing construction of additional disposal areas)
- all of the activities associated with closure of the GDF

It is noted that transport of radioactive waste would occur during the operational phase.

The assessment also considers demands placed on finite resources from elsewhere (mainly through requirements for construction materials) and waste management requirements (particularly related to the disposal of excavated rock) throughout the GDF's life cycle.

1.4.3 Geographic scope

The assessment does not focus on any specific area or site and considers generically the implementation of geological disposal within England, Wales or Northern Ireland. Scotland is not included as it is Scottish Government Policy that the long-term management of higher activity waste should be in near-surface facilities located as near to the site where the waste is produced as possible. However, where relevant, the assessment has considered the potential for transboundary effects on environmental receptors located in Scotland.

During the siting process, the potential effects identified in this report will be explored in greater depth and in the context of known local conditions. Such location-specific reports will include formal Environmental Impact Assessment (EIA) at the appropriate stage.

1.5 Document structure

The remaining sections of this report are structured as follows.

- Section 2: Methodology – explains the overall approach and methods used to assess the potential environmental effects of implementing geological disposal.
- Section 3: Assessment of effects – summarises potential beneficial and adverse environmental effects that may arise throughout the life cycle of the GDF. It is structured according to the twelve themes identified under 'Technical Scope'.

- Section 4: Conclusions – presents the key conclusions from the assessment.
- Glossary: Every effort has been made to write this report in the most accessible language possible. However, the subject matter is unavoidably technical and it has not been possible to avoid the use of some technical terms. To assist in understanding these, a glossary of technical terms and abbreviations is provided in the Technical Background document [3].
- Appendix A : Presents baseline information across the twelve themes, at a national or regional level. It considers both the current situation and how the baseline might change over time, providing a yardstick and useful context for the assessment work.
- Appendix B : Provides additional detail on the assessment work across the twelve themes.

2 Methodology

2.1 Understanding potential effects on the environment

The environment is the totality of the surroundings in which we live – the earth, atmosphere and oceans; land, rivers and seas; the air we breathe and sounds we hear; our homes and the communities they form part of; the farms from which our food comes and the natural environment that surrounds it all. It can be considered at a global scale in terms of oceans, atmosphere and climate change, or a very local scale in terms of specific wildlife habitats, local air quality or the view from an individual property.

In order to understand how the GDF might affect the environment, it is necessary to understand a number of different concepts:

- **The baseline environment** – this is defined as the situation in the absence of geological disposal, at any defined point in time. In other words, this is the environment that would be affected by any phase of the development: construction, operation or closure of the GDF, including the siting process. This includes both existing conditions and 'future baseline conditions' that may develop over time if the GDF was never developed. Such future conditions may arise from factors such as future climatic conditions or any noteworthy and reasonably foreseeable changes and trends relevant to each theme.
- **The phasing of the development** – each phase of the development would affect the environment in different ways and over different timescales.
- **Environmental objectives and targets** – consideration of environmental effects at a generic level is normally carried out against a suite of objectives and targets, and not in terms of effects on specific environmental features. This is in part because, at a generic stage, specific sites are not yet under consideration, so effects on specific features cannot be identified. Such an approach is also better able to support the strategic thinking required at this stage of project development, leading to more sustainable decision-making. More information on this is given in Section 2.4.
- **Beneficial and adverse effects** – some effects on the environment are likely to be beneficial, while others are likely to be adverse. The focus in all stages of environmental assessment is twofold:
    - firstly, on seeking to avoid or, if that can't be done, to reduce any adverse effects
    - secondly, on seeking to maximise and enhance beneficial effects

    Both of these can be most effectively achieved where environmental factors are built-in to decision-making from the very earliest stages of a project.

2.2 Baseline information

As no potential locations for the GDF have been identified and this assessment has been undertaken on a generic basis, it would be impractical to collect detailed baseline information for the whole of England, Wales and Northern Ireland (and, where relevant, Scotland). The baseline information provided in Appendix A therefore consists primarily of statistical and other information on each of the 12 themes at a national or regional level. This information provides a yardstick and useful context for the assessment work.

2.3 Approach to future conditions

For planning purposes, RWM currently assumes that the operational phase of the GDF will run from circa 2040 to 2190, followed by a 10-year closure period. It is important to recognise that the baseline environment is likely to change over this period.

Appendix A describes potential future conditions, with a particular focus on the effects of climate change (based on climate change predictions, such as the UK climate projections known as UKCP09). The broad changes to long-term, seasonal averages and extreme weather events, based on the projected changes to the UK climate available up to 2080, are described in the climate change section of Appendix A, with the potential impact on relevant receptors (for example soil quality and air quality) defined under each theme. In addition, any noteworthy and reasonably foreseeable changes and trends, based on published guidance, are described under each theme in Appendix A. The future baseline conditions set out in Appendix A take into account information from Geological Disposal: Identifying the research required to establish an environmental and socio-economic baseline for Strategic Environmental Assessment (SEA) and EIA [10].

There is a high level of uncertainty in predicting future conditions and therefore the main assessment considers only the current baseline conditions. Consideration has then been given to how future baseline conditions (set out under each theme in Appendix A) might affect this assessment under each theme. This is presented in Appendix B with commentary on whether potential future conditions could change the extent to which the development contributes to the achievement of the environmental objective or whether the potential future conditions are too complex/uncertain to allow an assessment to be made at this stage. Operational phase baseline monitoring and improved forecasting of future conditions are expected to reduce uncertainty in this regard. Consideration could also be given to long-term storage of environmental samples to build an environmental memory of the site and surroundings. This could be delivered through a facility similar to the 'Ecotheque' project associated with a proposed geological disposal facility at Bure, in France [11]. The Ecotheque facility aims to store samples to ensure their traceability and integrity for at least 100 years.

2.4 Assessing the environmental effects

The assessment considers the extent to which implementation of the GDF will contribute towards the achievement of a range of objectives, relative to the baseline situation.

The assessment has been conducted under 12 environmental themes, against each of which a principal objective has been defined (see Table 1).

The six-point qualitative scoring system set out in Table 2 has been used to assess environmental effects based on the extent to which the implementation of geological disposal is likely to contribute to the objectives.

At this generic stage, the information available does not support quantitative assessment. The assessment made using the system described in Table 2 is, therefore, made on a qualitative basis, using professional judgement and experience.

Table 1 Environmental themes and objectives

Environmental theme	Objective
Landscape and Visual	Maintain and enhance the quality and character of the landscape, seascape and townscape and to maintain and enhance existing views. Seek to minimise any adverse effects on quality, character, views and light pollution.

Environmental theme	Objective
Cultural Heritage	Minimise detrimental effects on heritage assets and their setting. Seek to enhance the recording, conservation and preservation of assets and their settings.
Geology and Soils	Prevent and reduce contamination and safeguard soil quality and quantity, together with features of geological interest. Where land is affected by contamination, remediate to a condition suitable for use.
Water	Maintain and enhance water quality, minimise abstraction to conserve resources at sustainable levels. Minimise the risk of flooding.
Biodiversity, Flora and Fauna	Protect, enhance and promote natural biodiversity and habitats and seek to avoid their fragmentation.
Traffic and Transport	Minimise the need to travel, particularly by car or lorry, and minimise the levels of road congestion, maintaining and improving, where appropriate, travel facilities and choices and minimising the environmental effects of traffic. Seek to encourage alternative modes of travel (other than by car/lorry).
Air Quality	Minimise the emission of pollutants and air quality impacts relative to statutory levels, where possible. Seek to enhance air quality through opportunities locally to help achieve the objectives in the EU Directive 'on ambient air quality and cleaner air for Europe'.
Climate Change	Minimise greenhouse gas emissions, encourage adaptability to climate change and encourage the use of low carbon technologies. Promote energy generation from renewable sources.
Noise and Vibration	Minimise noise pollution and the effects of vibration. Seek to enhance existing conditions where possible.
Land Use and Community	Minimise consumption of, and reduce damage to, undeveloped land and agricultural holdings through re-use of previously developed land and existing buildings where possible. Protect and enhance recreational resources land and facilities valued by the local community.
Waste	Minimise the generation of waste and promote the application and adherence to the waste management hierarchy.
Resource Use, Utilities and Services	Encourage and promote the efficient use of resources (materials, aggregates, metal).

Table 2 Qualitative scoring system

Score	Description	Symbol
Major positive effect	Significant positive effects are likely and the implementation of geological disposal will contribute significantly to the achievement of the objective.	++
Minor positive effect	Positive effects are likely and the implementation of geological disposal will contribute to the achievement of the objective but not significantly.	+
Neutral / negligible	The implementation of geological disposal is not likely to have any positive or negative effects or the effects would be imperceptible. In some cases the objective may still be met.	N
Minor negative effect	Negative effects are likely and the implementation of geological disposal will detract from the achievement of the objective but not significantly.	-
Major negative effect	Significant negative effects are likely and the implementation of geological disposal will detract significantly from the achievement of the objective.	- -
Not scored	The theme is too dependent on site-specific information to allow an assessment score to be given at this generic stage.	x

The environmental effects of geological disposal are assessed against each of the themes defined in Table 1 for each phase of the GDF in terms of how they meet the objectives. The results of the assessment are set out in Appendix B and key points are summarised in Section 3.

2.4.1 Mitigation of environmental effects – general principles

Performance against the objectives has been considered in the absence of any detailed proposals for mitigation, monitoring or enhancement, as these are frequently site-specific. However, in broad terms, the potential for mitigation, monitoring and enhancement measures has been identified. Such opportunities will be considered further during the site selection process.

Certain principles will be applicable throughout the life cycle of the GDF. These principles are based on the 'mitigation hierarchy':

- **Avoidance** – where there is potential for a significant negative environmental effect, the first option is always to avoid the effect, through selection of an alternative location, alternative technology or other changes to the development.
- **Minimisation** – where avoidance is not possible, action is required to reduce and/or minimise potential negative effects, through changes in design and/or other actions during construction, operation or closure (for example the application of environmental management plans). Any negative effect that remains after minimisation efforts are taken into account is sometimes referred to as a 'residual effect'. Examples of minimisation measures might include:
    - changing the layout of a development or the horizontal or vertical alignment of a transport route to reduce the proportion of an environmental receptor directly affected or the visibility of the development in the landscape
    - provision of noise barriers or visual screening to reduce noise nuisance or visual intrusion for nearby residents.

- **Compensation** – where neither avoidance nor minimisation efforts have completely removed a negative effect, or reduced it to an acceptable level, then works are generally required to compensate for the unavoidable residual effect as appropriate. Examples of compensation measures could include:
    - replacement habitat for a protected species or improvements to existing habitats, sometimes with translocation of an affected population of the species, to compensate for a residual effect on such habitats or species
    - replacement of a community resource at another location, for instance by creation of a new facility to replace one that would be lost
    - undertaking an archaeological excavation to make a detailed record of an archaeological site that cannot be avoided, and publishing a detailed report to put the results into the public and academic domain
- **Enhancement** – It is important that developments consider the opportunity to provide an overall net gain, referred to as 'enhancement' measures. This is in line with national planning guidelines such as the National Planning Policy Framework [12] which includes, as a core planning principle, a commitment to planning that improves and enhances the places where people live.

2.5 Taking uncertainty into account in the assessment

This assessment deals with the potential environmental effects of the GDF at a generic level, with no more precise assumption about its location than that it will be somewhere in England, Wales or Northern Ireland. This inevitably introduces a significant degree of uncertainty into the assessment. Key aspects of uncertainty are outlined below:

- GDF design – generic design options exist for the GDF, but no such design could ever be considered definitive for the purposes of assessment until it has been applied and adapted to a specific location to develop a site-specific design, taking into account local topography, drainage and access requirements.
- Geological environment – the geology of the UK is varied and complex. To facilitate the assessment, three generic rock types have been defined that broadly encompass all the many different geological environments in which the GDF could be located ('higher strength rock', 'lower strength sedimentary rock' or 'evaporite rock').
- Environmental characteristics of the GDF site and its surroundings – these are clearly unknown at present, but are fundamental to environmental assessment. This assessment has focussed on characterising the types of effect that could occur in a generic way, in relation to each environmental theme.

These sources of uncertainty are recognised and taken into account in the level of detail to which environmental effects under each environmental theme have been assessed, and the extent to which each aspect of the development has been considered in the assessment. Where possible, consideration has been given to changes in environmental conditions over the lifetime of the GDF.

For some topics it has been concluded that site-specific information is needed to allow a meaningful assessment to be made. These topics are identified as 'not scored' as described above (Table 2) and will be the subject of further study during the siting process.

The degree of uncertainty will reduce throughout the siting and future assessment processes. However, any remaining areas of uncertainty will be reported at each stage, including within any formal EIA.

2.6 Cumulative effects

As the potential location of the GDF has not been identified and the project timescales are very long, it is not possible to identify individual projects or proposed developments that might be relevant to an assessment of cumulative effects. This would require consideration of the potential relevance of all significant development projects in England, Wales and Northern Ireland over an unreasonably long timescale, and this is considered to be both impracticable and not meaningful. For this reason, this assessment does not consider the cumulative effects of geological disposal together with other projects. Cumulative effects will be considered to the extent that it is considered practical during later stages of the siting process.

3 The Assessment of Effects

3.1 Introduction

This section summarises the potential effects that the GDF could have on the environment across its whole life cycle as well as considering key opportunities for mitigation, monitoring and enhancement. A summary of the assessment is provided in Section 3.14, including Table 3, and more detail of the assessment is given in Appendix B.

3.2 Landscape and visual effects

Box 1. Environmental objective

Maintain and enhance the quality and character of the landscape, seascape and townscape and maintain and enhance existing views. Seek to minimise any adverse effects on quality, character, views and light pollution.

3.2.1 Summary of baseline

The landscapes of the UK are protected by national designations, including National Parks (England, Wales and Scotland), Areas of Outstanding Natural Beauty (England, Wales and Northern Ireland) and National Scenic Areas (Scotland). In some cases, international designations, such as World Heritage Sites and Biosphere Reserves may also take into account landscape, townscape and seascape characteristics or elements.

The character of landscapes, townscapes and seascapes is generally site-specific and may be influenced by geological conditions (because rock type affects drainage, landform and soil chemistry).

Visual baseline conditions are also site-specific. Visual receptors typically include people living and working in the area, people passing through by road, rail or other forms of transport, people visiting promoted landscapes or attractions and people engaged in recreation [13].

3.2.2 Typical generic effects

It is recognised that the site of the GDF, and the surrounding area affected by it, may include designated and non-designated landscapes, seascapes or townscapes. Each will have its own character, special qualities and value (whether designated or not). The existing visual resource and the visual amenity of receptors will vary depending on the site selected. Typical generic effects of development works on the landscape and views can include:

- loss or fragmentation of, or damage to, landscape and townscape elements (such as individual trees, hedges, walls and field patterns) and changes in landscape, townscape and seascape character
- visual intrusion through the introduction of new, contrasting elements into existing views or the obstruction of existing views, including light pollution

The degree to which these effects will occur, and the extent to which they are likely to affect achievement of the objective set out above will vary throughout the life cycle of the GDF, influenced by the nature and scale of the works and their relative permanence.

3.2.3 Summary of effects during siting process

The earliest landscape and visual effects are likely to occur as a result of the geological investigation of potential sites. Surface based investigations will include seismic surveys and drilling of deep boreholes at and around each of the potential sites. While the investigation could take around a decade (although this is dependent on the geology of the sites being investigated), the visual intrusion from drilling boreholes is anticipated to be relatively short term (approximately six months per borehole) at any given location and the landscape and visual effects of these works will therefore be amenable to effective reinstatement/mitigation.

Performance against environmental objective

As set out above, there is some potential for negative effects on landscape character and views associated with the siting process, primarily through the introduction of new features associated with drilling. These effects will be limited in their geographical scale and therefore effects on more sensitive features or views may be able to be avoided. In addition, effective restoration of areas affected by temporary drilling rigs is likely. Without mitigation, localised negative effects are likely and, therefore, the siting phase may detract from the achievement of the objective. However, restoration will ensure that such effects are temporary and unlikely to be significant.

In some cases, opportunities may exist to improve the visual baseline and enhance the landscape character, for example through planting. Mitigation will need to be site-specific, to reflect the particular features of the receiving landscape and the proximity (or otherwise) of the works in relation to visual receptors.

3.2.4 Summary of effects during the initial construction phase

Once a site has been identified for the GDF and construction begins, the principal landscape and visual effects will relate to construction of the surface facilities (on an assumed footprint of around 1.4 square kilometres (140 hectares), construction of new transport links and storage of material arising both from stripping of surface materials/earthworks and from initial underground excavations.

The construction phase is expected to last ten years and to be confined to the GDF site, any new transport links and associated infrastructure. A landscape strategy will be implemented during the initial construction stage, with suitable management measures remaining in place throughout the subsequent phases of GDF development.

The indicative designs include mounds around the edges of the surface site. The approach to development and management of mounds will depend on both the host rock type and the specific site identified (for example available land area and topography). Mounds provided primarily for screening purposes will be designed and modelled to provide sympathetic visual screening of surface facilities (they will probably not be straight sided ‘engineered’ mounds). These mounds will be located and designed in such a way as to screen ‘visual clutter’ associated with the lower elements of the surface facilities. The key differences between the uses of mounds for the three different rock types are summarised below.

- For all host rock types, mounds could be formed from surface materials won from site clearance and from excavation of a drift and / or shafts in rocks overlying the actual host rock. Such mounds may remain undisturbed for the lifetime of the GDF and could therefore be suitable to provide landscape mitigation and visual screening. Where appropriate, their visual screening effect could be enhanced by establishing tree and shrub planting on them, if suitable depths of subsoil and topsoil are used in the formation of the mounds.

- On a higher strength rock site, some of the excavated host rock is likely to be stored in surface mounds for re-use in backfilling, with the intention that it could be used during both the operational and closure periods. Some or all of these 'storage' mounds are likely to remain undisturbed for long periods, so there would be the potential to establish vegetation on them, if suitable depths of subsoil and topsoil are used in the formation of the mounds. However, mounds storing material to be used for backfill are not anticipated to be primarily designed for landscape/visual mitigation purposes.
- On a lower strength sedimentary rock site, material from the host rock may not be suitable for backfilling and could be used to form mounds. Therefore, mounds formed of this material could be used to serve a principally landscape/visual screening purpose and could be enhanced with vegetation, if suitable depths of subsoil and topsoil are used in the formation of the mounds.
- On an evaporite rock site, material from the host rock is currently assumed to be unsuitable for storage in surface mounds. Therefore, mounds are likely to be formed using subsoil and topsoil arising from the surface strip and, if required, imported material.

These differences in the make-up and use of the mounds and the likelihood/frequency of disturbance will influence the potential for visual intrusion and the visual screening required. Consideration will be given to the locations in which vegetation is allowed to establish in order to avoid the need to remove established mature vegetation during closure of the facility. For example, mounds primarily intended to provide storage of material for backfilling could be located inside the visual screening mounds.

The visual screening provided by mounds will form part of a landscape strategy designed to suit the location. Other parts of the strategy are likely to include the creation of new landscape features or elements and may include planting in locations away from the mounds – perhaps including 'off-site' planting. Where appropriate, opportunities for enhancement in relation to existing conditions (for example, reinstatement of degraded hedgerows or valued landscape features) will be explored.

Performance against environmental objective

As a result of the amount of land likely to be affected by the GDF, the nature of the construction works required and the duration of the effects, negative effects on landscape character and views are likely during the initial construction phase. As set out above, this is the phase during which the greatest changes in landscape and views will occur. The degree to which such effects will be significant is dependent on the nature of the environment, including factors such as topography, openness and the proximity to visual receptors. Without mitigation, significant negative effects may occur and, therefore, the initial construction phase is likely to detract from the achievement of the objective.

As discussed above, there is considerable potential for mitigation and, in some cases, enhancement to be put in place during the initial construction phase. This is likely to include the effective use of mounds and planting. The degree to which this will mitigate effects will be dependent on factors such as the existing landscape character. Suitable planting in a degraded landscape may result in significant enhancement, whilst the potential for mitigation and enhancement may be more limited in open landscapes where planting may not be characteristic. In all cases, mitigation will improve the likelihood of meeting the objective, although it should be noted that measures are likely to take some time to become established. In some cases, enhancements to existing conditions may be achievable in the longer term.

3.2.5 Summary of effects during ongoing construction and operation phase

The GDF will be in operation for many decades, during which time most activity will be underground. Although the surface site will be busy during the operational phase, any on-going changes to the surface facilities are unlikely to add significantly to existing effects on landscape and views. The highest elements on site during operation are likely to be the discharge emissions stack and the shaft headworks buildings. The height of the emissions stack would be determined based on the site topography and dispersion modelling. In the generic designs the shaft headworks buildings have an indicative height of 30 metres. They are likely to remain visually intrusive, although this will reduce as any trees and shrubs planted during the initial construction phase grow and mature. The ongoing storage of excavated rock on the surface and its movement around the site may be the most visually intrusive activity. Again, this effect may be reduced in the case of an evaporite rock site, as it is assumed that less rock will be stored on site and any store will have to be covered. With a higher strength rock or a lower strength sedimentary rock, excavated spoil will have to be transported off-site if/when the capacity of surface mounds has been reached.

Operational lighting will be required to illuminate working areas. This will include security lighting to illuminate the security and perimeter fencing and amenity lighting for access roads and car parks and at a low level for footpaths. There is a risk that this lighting, particularly the security lighting, may create light pollution beyond the site boundary, although the significance of such an effect will depend on the nature and proximity of any receptors present. Particular care will be taken in the specification and siting of all surface lighting to minimise light spillage. Screening mounds are likely to be outside the inner security fence and could be designed to minimise light pollution, especially as tree planting on them becomes more mature. It may be necessary to light the outer perimeter fence, beyond the mounds for security purposes. Consideration will be given to the need for and design of any lighting in this location to minimise light pollution where practicable.

It is anticipated that landscape and visual mitigation and enhancement measures will be implemented during the initial construction phase. The subsequent effectiveness of such measures will be monitored and suitable management will be implemented to ensure that planting becomes well established and provides an effective contribution to visual screening.

Performance against environmental objective

There is some potential for negative effects on landscape character and views associated with the ongoing construction and operational phases, primarily through continued activity at the site. These effects will be more limited than those occurring during the initial construction phase. Without mitigation, some negative effects are likely and, therefore, the ongoing construction and emplacement of waste may detract from the achievement of the objective.

The mitigation put in place during the initial construction phase will become more established during this phase and, therefore, with this in place the objective may be met and in some cases existing conditions may be enhanced. The degree to which this is likely to be the case will depend on the site-specific conditions, including the landscape condition and character and the proximity to visual receptors.

3.2.6 Summary of effects during and after closure

The closure of the GDF will initially involve backfilling and sealing of the underground facilities, then closure, decommissioning and demolition of the surface facilities.

Visual effects during the initial backfilling/sealing activities will be broadly similar to those during operation. The scale of these activities relative to operation will depend on the

approach taken to the backfilling of disposal facilities (and the extent to which backfilling of disposal areas is undertaken during the operational phase). Effects during decommissioning and demolition of the surface facilities may be more similar to those during construction, although of shorter duration. Subject to the site-specific landscape strategy, these effects are likely to be reduced by the presence of very well established landscape planting which would, by then, be over 100 years old.

Performance against environmental objective

There is some potential for limited negative effects associated with closure activities, although these will occur after a longer period of operation during which the presence of the GDF (with associated activity) and any planting will have become established as the baseline condition.

Post closure, the site will be restored to an end-state agreed with the local community. This could have a positive effect if intrusive features are removed while any landscape mitigation established at earlier stages is left in place. This could include the peripheral surface mounds and planting, where these have become part of the landscape baseline.

With mitigation or enhancement measures in place, there may be potential for positive effects. The objective may be met if, for example, established improvements to the landscape provided as a result of the GDF are maintained or if the site is restored in a way that provides an improvement in landscape condition or views.

3.3 Cultural heritage

Box 2. Environmental objective

Minimise detrimental effects on heritage assets and their setting. Seek to enhance the recording, conservation and preservation of assets and their settings.

3.3.1 Summary of baseline

The UK has a rich cultural heritage going back over 10,000 years, and the entirety of the British landscape has been modified by human activity. Hundreds of thousands of archaeological sites and historic buildings are present, but very unevenly distributed. Most archaeological sites are invisible above ground, but a very small proportion of the most robust or exceptionally well-preserved sites are visible and can be iconic national monuments.

3.3.2 Typical generic effects

In generic terms, potential effects on cultural heritage assets can include:

- direct disturbance, damage or loss
- indirect damage, for instance through dewatering ground that contains archaeological remains preserved through waterlogging
- fragmentation or severance of linked features
- changes to the setting of a historic building or ancient monument

It is not possible to identify the effects of the GDF at this stage, as without knowledge of its location it cannot be determined whether historic buildings, archaeological sites or historic landscapes will be affected. However, some generic comments on how the effects could vary through the lifetime of the GDF, assuming some heritage features are present, can still be made.

3.3.3 Summary of effects during siting process

In the case of direct disturbance, damage or loss of historic features, particularly archaeological remains, any damage is usually permanent even if the works that cause this are temporary. Archaeological remains are mostly found in the top 1 metre of soils or underlying materials, and are rarely found below 3 metres from the surface except in unusual city-centre locations or in mining areas, so even very shallow works would damage them. Conversely, once this depth has been passed, it is very unlikely that any further damage would be caused. Known assets may be able to be avoided during the borehole works for this phase and effects would be limited in terms of the area affected.

Changes to settings during the siting process, for instance if borehole drilling equipment needs to be set up near historic buildings, would be short term and the original setting could generally be reinstated.

3.3.4 Summary of effects during initial construction phase

During this phase, any physical disturbance or excavation of land required for the construction process is likely to result in permanent effects on archaeological remains. It is possible that some above ground historic features may also be affected by direct physical loss, depending on the location.

Once construction starts, impacts on the original setting of any historic sites in the surrounding area will be longer term, so mitigation would be through provision of screening and other designed landscape features, in close collaboration with the landscape strategy. Where appropriate, opportunities to enhance the historic environment, for example through improvements to the setting of heritage assets or improved interpretation and access could be explored.

3.3.5 Summary of effects during ongoing construction and operation phase

No new effects are likely to occur during the ongoing construction and operational phase, so long as the surface footprint and general design/layout of the GDF remains constant. As the planting elements of the landscape strategy grow and mature, particularly during the operational phase, the visual intrusiveness of the GDF in the historic setting of any relevant sites will reduce.

As set out for the landscape theme, it is anticipated that mitigation and enhancement measures are likely to be implemented during the initial construction phase. Therefore, during this phase, the effectiveness of such measures would be monitored, including suitable management to ensure that planting becomes established.

3.3.6 Summary of effects during and after closure

No new effects are expected during the closure period. Post-closure, the site will be restored to an end-state agreed with the local community. There may, therefore, be scope to recreate the pre-GDF setting of any heritage features in the immediate vicinity. It will be necessary to make a judgement as to how appropriate and relevant this will still be, depending on policy current at the time and on any other changes in the surroundings that have taken place independently of the GDF in the intervening decades.

3.3.7 Performance against environmental objective

There is some potential for negative effects on heritage associated with the GDF and, in particular, during the initial construction phase. The land take required for the GDF could affect built heritage features, the historic landscape pattern and known or unknown buried archaeology. In addition, the scale of the works required may result in effects on the setting of heritage resources. Although it is likely that some effects could not be avoided,

the nature of such effects and their significance will be dependent on the actual environment, the nature of the resources affected and the value placed on them. Similarly, the degree to which such effects can be mitigated will be highly site-specific. Therefore, at this stage the performance against the objective has not been scored.

3.4 Geology and soils

Box 3. Environmental objective

Prevent and reduce contamination and safeguard soil quality and quantity, together with features of geological interest. Where land is affected by contamination, remediate to a condition suitable for use.

3.4.1 Summary of baseline

The geology of the UK is extremely varied, and the soils vary substantially from area to area, influenced by underlying geology, topography, climate and drainage. This has a significant effect on the quality and versatility of land use. Geology of particular interest at a national level is protected through designation, for example, through geological Sites of Special Scientific Interest.

The UK has a significant legacy of land contamination, often on existing and former industrial sites. These sites include metal and coal mining activities that have taken place over centuries, together with more recent industrial sites.

3.4.2 Typical generic effects

In generic terms, potential effects on soils and features of geological interest can include:

- removal of topsoil, reduced soil quality and low level contamination
- disturbance/remobilisation of contamination
- effects on important geological sites

The objective to prevent and reduce contamination and to safeguard soil quality and quantity is achievable through appropriate control measures. Safeguarding features of geological interest is possible through avoidance and, where land is affected by existing contamination, opportunities may exist to remediate these to a condition suitable for use. Potential effects on the agricultural value of soils are considered separately in Section 3.11.

3.4.3 Summary of effects during siting process

During the siting process, borehole drilling surveys will affect relatively small areas of land and soils at multiple sites around potential host communities. These effects will in general be temporary, as the drilling works at each site are anticipated to take around six months per borehole and the sites will be reinstated, although soil quality may be affected for a period. At some of the borehole sites, after completion of the drilling works, smaller-scale works may continue on a smaller footprint. In such cases testing equipment may be left in place in the borehole for environmental monitoring, which would require periodic revisits to the site with small plant. Normal site investigation and construction management techniques will control effects on soils and land quality (for example through effective procedures to deal with spillage). At all sites, but particularly if a brownfield site is considered within the siting process, a strategy will be required to deal with any existing contamination identified during drilling works.

Performance against environmental objective

There is some potential for negative effects on geology and soils associated with the siting process, primarily through the drilling activities. These effects will be limited in their geographical scale and therefore effects on more sensitive features, such as sites of geological interest, may be able to be avoided. In addition, effective restoration of areas affected by temporary boreholes is likely. Without mitigation, localised negative effects are likely and, therefore, the siting phase may detract from the achievement of the objective. However, restoration will ensure that such effects are temporary and unlikely to be significant.

As set out above, mitigation of effects arising during the siting phase is likely to be possible through the adoption of normal site investigation and construction techniques. In line with the environmental objective, opportunities may exist to remediate any existing contamination and improve soil quality and quantity at borehole drilling locations. Therefore, it is likely that the objective could be met with suitable mitigation in place.

3.4.4 Summary of effects during initial construction phase

The initial construction of the GDF will result in the displacement of topsoils and subsoils associated with the surface facilities and infrastructure, followed by the excavation of large volumes of rock, first from the surface geological deposits overlying the host rock formation and then from the host rock formation itself. Similar to the management of a deep mining site, solid waste arising from the excavation will require characterisation and, depending on the rock types, appropriate measures and facilities for its use, storage or disposal.

In common with any large construction process, there will be some risk of environmental damage (contamination of land) from spills of fuels, oils or other construction materials; siltation from surface drainage. These risks can be controlled through environmental management plans and provision of an effective site drainage strategy. In the event that the selected site has been subject to previous contamination, a strategy to address this and remediate the area would be required.

Depending on the location, opportunities may also exist to improve access to and interpretation of sites of geological interest local to the GDF.

Performance against environmental objective

Geology is a key factor considered in the generic design for the GDF. The site selection work will ensure that there is a good understanding of geological conditions prior to construction commencing. Nevertheless, there will be some unavoidable effects on geology and soils associated with the initial construction process as a result of the significant excavation works and soil handling operations required. This has the potential to detract from the objective when considered without mitigation.

Although the initial change in geological conditions arising from excavation of the GDF cannot be avoided, mitigation is likely to be effective in relation to contamination, spillage control and effective soil handling. In some cases, there may be opportunities to provide enhancements to existing conditions through remediation of existing areas of known or previously undiscovered contamination. Therefore, with suitable mitigation in place it is likely that the objective could be met.

3.4.5 Summary of effects during ongoing construction and operation phase

Following initial waste emplacement, construction of further underground disposal areas will continue alongside ongoing waste emplacement. Effects during this stage are anticipated to be similar to those identified for the initial construction stage (excavation of

material and risk of spillage), although activities are likely to be less intensive over a longer period of time.

Depending on the nature of the host rock, some material may need to be exported during the operational phase. For an evaporite rock, material may need to be exported off site throughout the operational phase. For lower strength sedimentary and higher strength rock types, some material may need to be exported off site if the capacity of the surface site to store material is exceeded. Some benefits could arise from the potential re-use of excavated materials elsewhere, offsetting the need for mineral extraction for construction and industrial minerals in other areas.

Performance against environmental objective

As set out above, the ongoing construction activity during this phase would result in effects similar to those considered for the initial construction phase, albeit that the rate of excavation will be slower than in the initial construction phase. Therefore, there will continue to be some unavoidable effects on geology and soils associated with the ongoing construction process in relation to continued excavation works and soil handling operations. This has potential to detract from the objective when considered without mitigation.

As for the initial construction phase, mitigation is likely to be effective in relation to contamination, spillage control and effective soil handling. In some cases, there may be opportunities to provide enhancements to existing conditions through remediation of existing areas of known or previously undiscovered contamination or through beneficial reuse of excavated materials. Therefore, with suitable mitigation in place it is likely that the objective could be met.

3.4.6 Summary of effects during and after closure

During closure of the GDF, below ground facilities would be backfilled and sealed. The effects of this will be controlled through the use of suitable backfill materials (in some cases, using previously excavated host rock) and techniques in line with the regulatory regime and good practice guidance in place at that time.

Surface activities will be similar to those during the initial construction phase. Once these activities are completed, the site will be restored to an end-state agreed with the local community. There may, therefore, be scope to restore the previous land use, if that is considered appropriate at that time.

Performance against environmental objective

The closure phase will require additional activity on the site, including further movement of materials associated with backfilling and closure. This has some potential to detract from the objective when considered without mitigation.

Although further changes arising from the movement and placement of materials cannot be avoided, mitigation is likely to be effective in relation to contamination, spillage control and effective soil handling. Once closure activities have been completed, any ongoing effects on geology and soils will be dependent on the final land use. With suitable mitigation in place it is likely that the objective could be met.

3.5 The water environment

Box 4. Environmental objective

Maintain and enhance water quality, minimise abstraction to conserve resources at sustainable levels. Minimise the risk of flooding.

3.5.1 Summary of baseline

In relation to surface water quality, significant progress has been made over the last 20-30 years in cleaning up the UK's lakes and rivers. Nevertheless, data for 2014 indicate that many waterbodies across the UK do not yet meet the objective set in the Water Framework Directive ('good' status).

Water resources are unevenly distributed in the UK. Rainfall is highest in the west and north west. Areas to the east and south east are drier [14]. This is broadly reflected in the availability of surface water resources by region. In some river systems, the pressure caused by a combination of low rainfall and abstraction for agricultural, domestic and industrial use means that the flow in the river has to be artificially maintained by pumping water from boreholes into the upper reaches of the watercourse.

Groundwater resources are also under pressure in some areas, as a result of abstraction (with up to 80% of public supply coming from groundwater in the drier regions), pollution and saline intrusion due to abstraction in coastal areas [15]. The drier regions tend to coincide with the areas of highest population, leading to a mismatch of overall water availability per head of population [16].

3.5.2 Typical generic effects

Major engineering projects such as the development of the GDF can affect the water environment in a number of ways:

- effects on surface water or groundwater quality through spillages of oils, fuels or other chemicals and releases of effluent during operation
- effects on surface water quality through the release of silt in surface water run-off, particularly during construction
- increased flood risk, due to siltation of local watercourses, impediment of flood flows or rapid run-off from impermeable areas of the development
- effects on the availability of water resources, either through increased demand or as a consequence of effects on water quality

All of these typical generic effects can be avoided, or the risk of their occurrence controlled to an acceptable level, through good site design (including site selection), construction practice and environmental management.

3.5.3 Summary of effects during siting process

Effects during the siting process are most likely to arise during drilling operations at the borehole sites. The duration of drilling activity will be relatively short term. However, there will be some risk of effects on water quality associated with potential spillage or release of contaminants. The effects will be dependent to some extent on the nature of the sites, for example, proximity to sensitive ground and surface water resources.

Performance against environmental objective

There is some potential for negative effects on the water environment associated with the siting process, primarily through the drilling activities. These effects will be limited in their geographical scale and therefore effects on more sensitive features, such as sensitive ground and surface water resources, should be able to be avoided. Without mitigation, localised negative effects are possible and, therefore, the siting phase may detract from the achievement of the objective.

Such effects will be controlled through standard mitigation and monitoring measures that are well established and effective. In some cases, some improvement to existing

conditions may be possible. Therefore, with suitable mitigation in place it is likely that the objective could be met.

3.5.4 Summary of effects during initial construction phase

During the initial construction phase, the size of the site required for the GDF will result in a significant change in land use (up to 1.4 square kilometres) and is therefore likely to result in an increase in hardstanding/impermeable area. This has the potential to increase the rate of run-off and therefore flood risk. In addition, it is at this stage that any effects on existing water assets of particular value (such as watercourses) could occur. However, such effects will be considered during the siting and design process to ensure that effects are reduced as far as possible, for example through avoiding areas particularly vulnerable to flooding and avoiding existing features of value, where possible.

As for any large construction project, there will be a risk of effects on the quality of surface or groundwater through accidental releases of contaminants/silt and potential for increased flood risk in the vicinity of and downstream of the site. The risk of contamination associated with construction of surface facilities could be effectively controlled through standard pollution control measures. For example, it is assumed that the GDF will include the following:

- use of construction techniques and materials that will be designed to prevent the release of contaminants to surface or groundwater
- refuelling areas that will be bunded and sealed to prevent release of hydrocarbons or other chemicals into the environment

Flood risk during construction will be controlled through an effectively designed temporary drainage system to be put in place until the operational surface water drainage system is implemented.

With respect to underground construction, the detailed design will take into account the need for protection of groundwater resources and any existing groundwater abstractions. Groundwater control is likely to be required, with potential for effects on existing patterns of groundwater flow. This may include de-watering in the upper 10 metres or so of strata, followed by grouting or similar techniques at greater depths.

During construction, the site will be a significant user of water. It is also likely that large quantities of water will be pumped from underground to drain the underground workings. This will probably greatly exceed the quantity required for use on site and will need to be managed. Site design and the location of transport links will take into account areas identified to be vulnerable to flooding, avoiding these where feasible or providing appropriate mitigation and/or compensation measures to ensure that the GDF does not increase the risk of flooding.

The effect of controls during construction is that a number of negative effects on the water environment that would otherwise be hypothetically possible can be avoided or controlled. In addition to such measures, opportunities for enhancement (such as improvements to existing waterbodies) could be explored, where appropriate for the site selected.

Performance against environmental objective

Hydrology is a key factor considered in the generic design for the GDF. The site selection work will ensure that there is a good understanding of hydrological conditions, including groundwater movement and flood risk, prior to construction commencing. Nevertheless, there will be some unavoidable effects on the water environment associated with the initial construction process. The degree to which effects on groundwater, surface water and flood risk will be significant is dependent on the nature of the environment. However, the

initial construction phase has the potential to detract from the objective when considered without mitigation.

Although some initial change in conditions arising from excavation of the GDF cannot be avoided, mitigation is likely to be effective in relation to control of effects on water quality and flood risk. There is likely to be opportunity for enhancements to the water environment through improvements to existing conditions. The nature of such opportunities will be site dependent but could include, for example, measures to reduce existing flood risk, enhance existing surface water features or address areas of existing poor water quality. Therefore, with suitable mitigation in place it is likely that the objective could be met.

3.5.5 Summary of effects during ongoing construction and operation phase

During this phase, the rate of construction activity will reduce and will primarily focus on excavation below ground. Some risk of effects on water quality will remain. However, as for the initial construction phase, this will be effectively controlled through mitigation measures and monitoring.

The operational surface water drainage system will control the risk of flooding and contamination from surface operations during this phase. The potential for an increase in the frequency of extreme weather events and for changes in rainfall will be taken into account when designing the drainage system.

During its operation, it is expected that the GDF will as a matter of course include:

- facilities to control and, if necessary, treat water drained from the surface site and any water pumped from underground before discharge
- facilities to attenuate surface water run-off, preventing any increase in local flood risk
- either a connection to existing utility foul drainage networks or on-site facilities for treatment of foul drainage before discharge off site

Consideration will be given to sustainable drainage measures, such as capturing rainwater from roof areas, vegetated building roofs and rainwater harvesting. Where practicable, consideration will be given to minimising the area of impermeable surfacing to allow local groundwater recharge.

In addition to the above, it is anticipated that monitoring of ground and surface water quality will be undertaken.

Performance against environmental objective

As set out above, the ongoing construction activity during this phase would result in effects similar to those considered for the initial construction phase, albeit that the rate of excavation will be slower than in the initial construction phase. Therefore, there will continue to be some potential for effects on the water environment associated with the ongoing construction process. This has potential to detract from the objective when considered without mitigation. Operation of the GDF will also require a certain level of activity on site. As set out above, the design of the GDF will include measures to control drainage and flood risk as a matter of course.

Mitigation is likely to be effective in controlling effects on water quality and flood risk. In addition, any enhancements to existing conditions undertaken during the initial construction phase may continue to provide benefits during this phase. Therefore, with suitable mitigation in place it is likely that the objective could be met.

3.5.6 Summary of effects during and after closure

Effects during closure are likely to be associated with backfilling and with demolition of surface facilities. These activities could result in some effects similar to those arising during construction (such as changes to groundwater flow or spillage). By the time of facility closure, monitoring is likely to have resulted in a high level of understanding of the environment at the site and in the surrounding area. This, together with standard construction techniques to control spillage, will effectively control effects at this stage.

The end-state of the site will be agreed with the local community at the time. There is therefore some potential for enhancement measures, such as creation or reinstatement of features, such as streams and ponds, or improvements to the local water environment.

Performance against environmental objective

The closure phase will require additional activity on the site, including further movement of materials associated with backfilling and closure. This will therefore have some potential for negative effects as set out for the previous phases above. This has some potential to detract from the objective when considered without mitigation.

Mitigation is likely to be effective in relation to effects during this phase. Once closure activities have been completed, any ongoing effects on the water environment will be dependent on the final land use and the degree to which any enhancements are provided as part of the final end-state of the site. With suitable mitigation in place it is likely that the objective could be met.

3.6 Biodiversity, flora and fauna

Box 5. Environmental objective

Protect, enhance and promote natural biodiversity and habitats and seek to avoid their fragmentation.

3.6.1 Summary of baseline

The UK contains a number of internationally important habitats supporting internationally important populations of plant and animal species. Large areas of the UK are designated at international or European level as Ramsar sites (149 sites), Special Areas of Conservation (652 sites) or Special Protection Areas (270 sites). In addition, Sites of Special Scientific Interest (SSSIs) in England, Wales and Scotland and Areas of Special Scientific Interest in Northern Ireland total nearly 7,000 in number.

In addition to nationally protected sites, many habitat areas are protected through designation under local authority planning policies as ‘Local Wildlife Sites’ (under many different names). Habitat types of particular importance are identified in the national Biodiversity Action Plan, and there are local Biodiversity Action Plans throughout the UK and Northern Ireland. Biodiversity Action Plan priority habitats are not protected as such, but are a significant consideration in environmental assessment. Together, these habitats and species also provide wider ecosystem services.

Certain species of both plants and animals are protected by law, some at international or European level and some under various UK statutes. Some species, such as great crested newts, enjoy a high level of protection because they are very rare in Europe as a whole whilst being relatively more abundant in parts of the UK, so that the UK population is of European importance. Others, such as many reptile species, are very rare in the UK, often due to habitat loss, whilst being more abundant elsewhere, so that the UK population is particularly vulnerable.

3.6.2 Typical generic effects

In generic terms, activities associated with the development of the GDF could result in the following types of effect on biodiversity, flora and fauna:

- effects on designated/protected sites
- direct or indirect loss or fragmentation of habitat
- disturbance/displacement of wildlife as a result of noise, human presence and light pollution, potentially affecting breeding success and survival
- effects on biodiversity through accidental pollution incidents, contaminated run-off from surface drainage; or transport-related pollution
- effects on aquatic habitats from discharges of drainage from underground workings (changes in the volume and rate of flow and in water chemistry)
- effects on aquatic habitats and aquatic wildlife species if dewatering of underground excavations affects water levels in surface water bodies and wetlands

It is not possible to be specific about the effects of the GDF on biodiversity at this stage as without knowledge of its location, effects on habitats and wildlife species present on and around the site cannot be determined. However, some generic comments on how the effects could vary through the lifetime of the GDF, assuming some valuable ecological features are present, can still be made.

3.6.3 Summary of effects during the siting process

Negative effects during the siting process could arise as a result of the borehole drilling programme and associated activities. Such effects could include temporary habitat loss and disturbance (for example through activity levels and lighting). The temporary nature of the works means that, in combination with sensitive selection of drilling sites, there is a high potential for effective mitigation and site restoration. Opportunities may also exist to enhance natural biodiversity and habitats, where appropriate, at borehole locations.

3.6.4 Summary of effects during initial construction phase

The majority of the effects in terms of habitat loss at the GDF are likely to occur during the initial construction stage, during which surface facilities will be constructed together with key aspects of the underground facilities, such as drifts and shafts.

Avoidance or reduction of effects will therefore be important at this stage, through detailed siting and design as far as practicable. For example, loss of habitats of particular value can in some cases be avoided through detailed siting or through design changes. Fragmentation, mortality and disturbance effects can be limited through sensitive lighting and suitable levels of screening. Following identification of the existing conditions and the likely effects as a result of construction of the GDF, the potential for habitat creation or enhancement will be identified. If necessary, opportunities for the creation of compensatory habitat (for example through biodiversity offsetting) will also be explored.

3.6.5 Summary of effects during ongoing construction and operation phase

Negative effects during operation are anticipated to be more limited, and principally related to site management (for example disturbance from operational noise and light pollution, the risk of accidental pollution incidents, water management). These effects can be controlled through initial site design and through environmental management plans. Ongoing maintenance of biodiversity mitigation/enhancement features and monitoring of their success/establishment will be key activities to meeting the objective during this phase.

3.6.6 Summary of effects during and after closure

The initial stages of the closure process have the potential to cause negative effects similar to construction and operation, although generally on a smaller scale. The final stage of closure is the restoration of the site to an end-state agreed with the local community. As set out in the landscape section above, it is anticipated that the landscape strategy would allow for the retention of screening mounds (with associated planting), where appropriate. Together with the retention of ecological planting or habitat creation, which would have matured and gained value during the operational phase, there is the potential to recreate an environment of greater value than the one originally lost, depending on the nature of the final end-state agreed with the local community.

3.6.7 Performance against environmental objective

There is considerable potential for negative effects on biodiversity associated with the GDF, in particular during the initial construction phase. The land take required for the GDF will result in some loss of habitat. The type of habitat and the species it supports will be site-specific and cannot be determined at this stage. However, it is recognised that all habitats present in the UK have some biodiversity value or potential and therefore negative effects will arise from the initial construction phase in the absence of mitigation, which will detract from the achievement of the objective. The significance of such effects and the degree of compliance with the objective will be dependent on the receiving environment, the nature of the resources affected and the value placed on them.

There is likely to be considerable potential for improvements to existing habitats or the creation of new features of biodiversity value in most areas of the UK (either on or off site), which will contribute to the achievement of the objective. Habitats created or enhanced are likely to be subject to a management plan, which would support the objectives of the relevant Biodiversity Action Plan. The nature and type of mitigation will be determined by the nature of the receiving environment, as will the extent to which any negative effects can be fully mitigated. The degree to which the objective can be met will be determined by site-specific conditions. Therefore, at this stage the performance against the objective has not been scored.

3.7 Traffic and transport

Box 6. Environmental objective

Minimise the need to travel, particularly by car or lorry, and minimise the levels of road congestion, maintaining and improving, where appropriate, travel facilities and choices and minimising the environmental effects of traffic. Seek to encourage alternative modes of travel (other than by car/lorry).

For the purposes of this assessment, the objective has been broadly interpreted to include the environmental effects of transport and the opportunities for use of more sustainable modes of transport. It should also be noted that there are overlaps between the effects considered in this topic and some other themes, particularly air quality, biodiversity, noise and climate change.

3.7.1 Summary of the baseline

There is an established road and rail infrastructure in the UK that currently handles 139 billion tonne kilometres of freight via road and 19 billion tonne kilometres of freight by rail per annum [17]. The movement of construction materials and wastes to and from the GDF during construction and operation (including any excavated rock removed from the site and

radioactive wastes taken to site for emplacement), other construction traffic movements and staff movements may all have an effect on the traffic and transport network.

3.7.2 Typical generic effects of transport

A large infrastructure project such as the GDF introduces a number of new transport movements onto the transport network – at local, regional and national scales. It is these changes in transport movements that have the potential to affect the surrounding environment.

In generic terms, the transport requirements associated with a large engineering project such as the GDF can have the following types of environmental effect:

- severance to routes used by pedestrians/cyclists/equestrians and loss of amenity
- community severance
- severance of habitats and wildlife commuting/foraging/migration routes
- driver and pedestrian delay and safety implications
- transportation of mud and pollutants off site on vehicle wheels
- increases in noise and/or air pollution and the emission of greenhouse gases

Such projects can also present opportunities to improve existing conditions on a local transport network by, for example, providing pedestrian, cycling and equestrian facilities or helping to address existing severance, congestion and road safety issues.

Attainment of the objective is likely to be possible depending on the baseline traffic and transport conditions local to the GDF site, the transport strategy (in particular the degree to which the use of rail transport can be maximised over road transport) and the extent to which additional community investment might be used to address existing local transport problems.

Environmental effects of traffic related to biodiversity, air quality, noise and climate change are considered in the relevant sections of this report. Other relevant effects are considered below.

3.7.3 Summary of effects during the siting process

During the siting process, the borehole drilling programme will give rise to some road traffic, including both heavy goods vehicles and cars. The quantity of road traffic likely to be generated is relatively small, such that significant effects on the local community or the environment are unlikely to arise. RWM's transport logistics work indicates that there may be in the region of 40 car journeys per day per borehole rig (80 journeys for two borehole rigs). It is recognised that there may be some intermittent disturbance from transport movements.

Performance against environmental objective

A relatively small amount of traffic will be generated during the siting process, which will have some limited potential for temporary negative effects, which may detract from the achievement of the objective.

There is some potential for mitigation of effects arising during the siting phase. Mitigation will need to be site-specific, to reflect the particular features of the existing transport network and the accessibility of the site.

3.7.4 Summary of effects during initial construction phase

During construction, operation and closure of the GDF, it is assumed that freight transport will be served by both heavy goods vehicles (HGVs) road traffic and by a dedicated rail link. The intention is to maximise the use of rail as far as possible for the movement of bulk materials (delivery of construction materials, removal of excavated spoil, delivery of radioactive waste for placement and delivery of backfill materials), in order to minimise the use of HGV traffic. The balance between HGV movements and freight train movements is uncertain at this stage and may vary from time to time according to the source of materials being delivered or the destination of materials being removed. Nevertheless, it should be noted that the use of rail over road for bulk materials could significantly reduce the number of HGV movements during all phases of the GDF life cycle.

Transport movements associated with excavated rock spoil will vary depending on the host environment. Peak movements are anticipated to be up to approximately 123 HGV movements or one train per day. For an evaporite host environment, it is assumed that all excavated material will be exported from the site. In addition, transport of surface construction materials is anticipated to require up to around 10 trucks per day, while underground construction may require up to around 20 HGV movements. For all rock types, the daily truck movements for each construction material could alternatively be transported by one train per day.

Traffic flows arising from staff and visitor transport could peak at approximately 600 car trips per day. A purpose built park-and-ride facility on a main highway for staff and visitors could mitigate effects on the road network, while improved access to the GDF by public transport, pedestrian and cycle links could also be used to reduce the need to travel by car.

Potential effects on the environment and communities will be very dependent on the location of the GDF and the characteristics of the local transport network. Without site-specific information, it is difficult to assess potential effects, but there are in principle some potential effects relating to:

- severance to routes used by pedestrians/cyclists/equestrians and loss of amenity
- community severance
- severance of habitats and wildlife commuting/foraging/migration routes
- driver and pedestrian delay and safety implications
- transportation of mud and pollutants off site on vehicle wheels
- increases in noise and/or air pollution and the emission of greenhouse gases

A site-specific mitigation strategy will be developed to address any concerns identified, taking into account the nature of the local road and rights of way network. The White Paper on geological disposal [2] notes that it is likely that the GDF will involve major investments in local transport facilities, which would remain after the facility is closed. Opportunities to address existing concerns in relation to severance, accessibility, safety and delay will be fully explored and could include improvements to existing roads (better junction layout, improved safety measures and improved access for local landowners) or provision of new transport infrastructure to alleviate existing traffic-related problems. Provision of improvements to existing rights of way or creation of new routes to enhance connectivity and encourage greater use could also be explored.

Performance against environmental objective

This phase will result in the highest number of road traffic movements and this is likely to result in some effects on the local transport network and its users. For a site with an existing minor local road network with low levels of existing traffic flow, the degree of

change in terms of traffic flow is likely to be relatively high. This may result in a change in the experience for users of the local network. For a site where the existing road network is busier, it is likely that there would be a lower percentage change in flow. However, such roads may be closer to capacity, such that effects on delays and junction capacity may be more likely. Therefore, the significance of the effects will be dependent on the site selected. However, it is recognised that without mitigation, negative effects are likely and, therefore, the initial construction phase may detract from the achievement of the objective.

As discussed above, there is considerable potential for mitigation and, in some cases, enhancement to be put in place during the initial construction phase. This may include investment in improved routes and new transport infrastructure, as well as measures to minimise the number of road traffic movements. In all cases, mitigation will improve the likelihood of meeting the objective and in some cases enhancements to existing conditions may be possible in the longer term.

3.7.5 Summary of effects during ongoing construction and operation phase

During the operational phase, both construction and operational staff will access the GDF. However, the total number of vehicles associated with staff is likely to be lower than the initial construction phase (approximately 300 car journeys per day). During operation, there will be reduced levels of transport associated with bulk materials, although movements of spoil are likely to continue. Deliveries of radioactive waste will commence during this period. At this stage it is assumed that the transport of radioactive waste will result in a peak of around 7 HGVs and less than one train per day for low heat generating waste and 1 train per week for high heat generating waste.

A visitor's centre is anticipated to be in place during this phase. Visitor numbers may peak in the summer months if the GDF is located near a tourist destination. However, it is also anticipated that educational trips for pupils and students will be a relatively high proportion of the visitors, with a less seasonal pattern.

Performance against environmental objective

As set out above, the ongoing construction activity during this phase would result in effects similar to those considered for the initial construction phase, albeit that the rate of excavation and activity will be slower than in the initial construction phase. Therefore, there will continue to be some effects on the local transport network and its users. This has potential to detract from the objective when considered without mitigation.

It is likely that mitigation or enhancement measures developed during the initial construction phase will remain appropriate during the ongoing construction and operational phase. Therefore, with suitable mitigation in place it is likely that the objective could be met.

3.7.6 Summary of effects during and after closure

During this phase, there will be continued staff activity on site, together with export of materials from the site and potential import of materials associated with backfilling, closure and site restoration (by HGV). The average number of staff journeys by car during this phase is predicted to be between 10 and 50 per day.

Performance against environmental objective

The closure phase will require additional activity on the site, including further movement of materials and personnel associated with backfilling and closure. This will therefore have some potential for negative effects as set out for the previous phases above. This has some potential to detract from the objective when considered without mitigation.

However, it is likely that mitigation and enhancement put in place in previous stages and maintained through the lifetime of the GDF will remain effective during this stage. With suitable mitigation in place it is likely that the objective could be met.

Overall, a transport strategy for the GDF will aim to reduce the number of transport movements to a minimum, where safe and practicable to do so. Measures to mitigate any potential negative effects will depend on the nature of the location. However, they could include improvements to facilities for active travel and public transport, provision of better information about alternatives to car transport and promotion of car sharing. Initiatives such as park and ride will be considered.

3.8 Air quality

Box 7. Environmental objective

Minimise the emission of pollutants and enhance air quality relative to statutory levels where possible.

3.8.1 Summary of baseline

Historically, the main sources of air pollution in the UK were the burning of coal and other fuels for domestic and industrial purposes and electricity generation, with some contributions from other industrial sources. However, the situation has changed radically in the last 30 years and the principal source of air pollution in the UK today is exhaust emissions from road traffic. In consequence, the areas with worst air quality tend to be in urban areas with heavy traffic, particularly along the arterial routes in and out of cities, and along the busier parts of the strategic road network that links the main cities.

Each local planning authority carries out a review and assessment of air quality within its administrative area, in relation to national air quality objectives. Where difficulties in meeting these objectives are identified, an Air Quality Management Area (AQMA) is declared, which is subject to a plan to improve air quality.

3.8.2 Typical generic effects on air quality

In generic terms, the emission of pollutants from traffic, industrial or domestic sources into the atmosphere can have a range of effects:

- in sufficiently high concentrations, some pollutants can affect human health
- some pollutants, such as oxides of nitrogen, can deposit out of the air onto the ground where they affect the soil in ways that are harmful to sensitive habitats
- other pollutants may be carried higher into the atmosphere where chemical reactions take place, creating acid rain
- at a very local level, dust in the air and settling out in the surrounding area can cause annoyance for local residents and can, in sufficient quantity, affect the growth of crops and other plants, and water quality

The pollutants of most concern in relation to road transport are nitrogen dioxide, particulate matter with a mean aerodynamic diameter less than 10 μm (PM_{10}) and particulate matter with a mean aerodynamic diameter less than 2.5 μm ($PM_{2.5}$). Other pollutants also arising from road traffic include volatile organic compounds. Ozone arises as a secondary pollutant from the action of sunlight on nitrogen dioxide and volatile organic compounds.

The Environmental Protection UK (EPUK)/Institute of Air Quality Management (IAQM) guidance [18] provides indicative criteria for determining when an air quality assessment is

required. Within an AQMA, the criteria for road traffic set out within this guidance document are:

- an increase of 100 annual average daily light duty vehicle flows
- an increase of 25 annual average daily heavy duty vehicle flows

Outside an AQMA, the criteria are:

- an increase of 500 annual average daily light duty vehicle flows
- an increase of 100 annual average daily heavy duty vehicle flows

There are no distances published in current guidance that define the study area for an air quality assessment of vehicle-related emissions. However, air quality professionals generally accept that pollutant concentrations reach background levels beyond a distance of around 200 metres from roads.

In relation to combustion plant (such as generators), the EPUK/IAQM guidance sets indicative criteria for determining when an air quality assessment is required (300 kW thermal input). No distances are published in current guidance defining the study area for such an air quality assessment and air quality professionals use their professional judgement to determine the study area based on the size of the plant.

For dust and PM_{10} effects on human receptors, the IAQM guidance [19] sets out 350 metres as the distance to be considered from the site boundary and 50 metres from the site traffic route(s) up to 500 metres from the entrance.

3.8.3 Summary of effects during the siting process

The initial siting phase will require some transport movements on a temporary basis and the drilling of boreholes. There will therefore be some potential for effects arising from traffic emissions to air and from generation of dust. Sources of dust could include construction of borehole drilling pads, compounds and access routes during the siting process. However, such effects are likely to be limited in comparison to the main construction phases of the GDF. The siting of the boreholes will be considered as part of the siting process and it may be possible to avoid sensitive residential receptors. Dust effects are considered in greater detail in the section below but it is noted that such effects can be minimised through well-established management methods.

3.8.4 Summary of effects during initial construction phase

During the initial construction and underground investigations phase, the estimated road vehicle trips, should road transport be the main transport method, could exceed the EPUK/IAQM indicative criteria. This has some potential to affect the achievability of the objective and a site-specific assessment will be required to determine the significance of any negative effects. The degree to which such effects may be significant will depend on the location of the GDF in relation to potential human and ecological receptors and existing air quality in the area. In the event that the GDF is located close to an area with existing air quality concerns (for example as a result of traffic), opportunities to provide an improvement to the existing situation may be explored. As set out in Section 2.5 and Section 3.7 above, the intention would be to maximise the use of rail as far as possible for the movement of bulk materials and radioactive waste. This will dramatically reduce the road vehicle trips such that it is unlikely that the EPUK/IAQM indicative criteria would be exceeded.

With respect to exhaust emissions associated with on-site construction plant, experience suggests that these are not likely to be significant [18]. Any air quality problems are therefore much more likely to be related to the generation of fugitive dust as a result of on-site activities. Relevant activities could include:

- general surface-based construction activities, including earthworks, soil stripping, storage and use of materials on site and excavations
- surface handling of excavated rock and other materials associated with vault and tunnel construction and backfilling during GDF operations

The risk of dust impacts can be minimised through well-established management methods and it is assumed that these would be implemented throughout the lifetime of the GDF. On this basis, no significant effects in relation to dust are expected.

3.8.5 Summary of effects during ongoing construction and operation phase

During this phase, some construction activity will continue, alongside the operation of the facility, including deliveries of waste to the GDF. The ongoing levels of construction activity and the overall staff numbers (and therefore traffic flows) will be less than during the initial construction phase. Traffic emissions can be effectively managed through measures such as maximising the use of rail transport and the provision of park and ride facilities for staff and visitors.

3.8.6 Summary of effects during and after closure

The closure phase will require a period of activity on the site, including demolition, clearance and earthmoving activities that have the potential to give rise to dust emissions. The activities will require both staff and HGV traffic movements, with associated potential for emissions to air. Appropriate dust control and traffic control measures will need to be developed prior to closure, based on standards and best practice at that time.

3.8.7 Performance against environmental objective

As set out above, effects in relation to air quality will include effects relating to dust and emissions from vehicles. The initial construction phase will result in the highest number of road traffic movements and a considerable amount of movement of rock and soil and is therefore likely to generate dust and vehicle emissions. Similar activities will also continue during the subsequent phases. The significance of effects will depend on the proximity and nature of receptors. Dust effects tend to be limited to several hundred metres in most cases [19] and may affect people and habitats in the vicinity of the dust generating activity. Traffic emissions may have a wider zone of influence, in part due to the larger area affected by changes in traffic flow from a development site. However, it is recognised that without mitigation, negative effects are likely and, therefore, the initial construction phase may detract from the achievement of the objective.

Effective dust control measures are well established. Emissions from traffic could be overcome to a considerable extent through an effective transport strategy as set out above.

The potential for enhancement will be site-specific and may depend on whether there are any existing air quality concerns. Overall, mitigation will improve the likelihood of meeting the objective and in some cases enhancements to existing conditions may be possible.

3.9 Climate change

Box 8. Environmental objective

Minimise greenhouse gas emissions, encourage adaptability to climate change, encourage the use of low carbon technologies. Promote energy generation from renewable sources.

3.9.1 Summary of baseline

In the UK, it is anticipated that climate change will result in warmer, wetter winters with a greater proportion of precipitation falling as heavy events [20]. UK climate projections (such as UKCP09) suggest that there is a greater likelihood of drier summers, although the predictions cover a range of scenarios (including wetter summers).

Long term projections for the UK suggest that temperatures may rise by 3-4^{o}C and precipitation could fall by 10-40%, depending on region, over the next 60-70 years (note that this is one of several scenarios). Associated with this, extreme weather events, flooding and coastal erosion are likely to increase. The international scientific consensus, accepted by the European Union and UK Government and reflected in both European and UK law and policy, is that this process of climate change is significantly influenced and accelerated by human-created emissions of greenhouse gases.

Total UK emissions of greenhouse gases in 2013 were, provisionally, equivalent to 568.3 million tonnes of carbon dioxide equivalent [21]. By far the largest single contributor was the generation of electricity in power stations, which emitted 189.7 million tonnes of carbon dioxide equivalent (approximately a third of the UK total).

3.9.2 Typical generic effects on climate change

In generic terms, the construction, operation and closure of the GDF can potentially contribute to climate change through the following:

- carbon emissions from vehicle movements (both road and rail)
- carbon emissions from the use of powered plant on site (for example diesel generators, earth moving plant and drilling equipment)
- embodied carbon within the construction materials used on site, including backfill materials used throughout the operational lifetime of the GDF
- carbon emissions associated with energy use on site

3.9.3 Carbon emissions as a result of developing the GDF

A study was carried out in 2009-2010 to analyse the potential carbon footprint of the development of the GDF [22]. This study has been updated in 2015-16 [23], taking into account the revised inventory for disposal figures, the revised illustrative designs for the disposal facility and associated transport system, the revised construction and operational phase programmes, the revised assumptions regarding mode of travel for staff to and from site and additional and more detailed analysis of embodied material impacts. Although the findings do not readily separate into the same key phases of development set out in other sections of this report, the key conclusions can be summarised as follows.

- During the siting process, construction and operation of the deep boreholes is estimated to generate in the region of 5,800 tonnes of carbon dioxide in total (irrespective of rock type).
- During construction, the upper end of the range of possible emissions was around 1.4 million tonnes over the construction period.
- During operation, carbon emissions are estimated at approximately 1.5 million tonnes of carbon dioxide, when transporting waste packages by road and rail and around 1.4 million tonnes when transporting waste packages by sea, road and rail, during an operational period of more than 100 years.

- During closure, the upper end of the range of possible emissions was over 5.2 million tonnes of carbon dioxide over a 10 year closure period[3].

Taken together, these figures suggest maximum emissions, including embodied carbon, of around 7.3 million tonnes of carbon dioxide. These emissions would occur over a period of more than a century.

3.9.4 Performance against environmental objective

The GDF will be designed in line with RWM's sustainable design objectives [24], which include objectives/approaches for minimising embodied carbon. There is some potential for negative effects in relation to the objective. The carbon report compares the estimated carbon emissions with other large infrastructure projects. This concludes that the other projects generally have a lower proportion of embodied carbon than that estimated for the GDF. Otherwise, given the relative scale and nature of the projects they are broadly comparable.

The GDF will also be an essential part of the plan for the continuation of nuclear electricity generation in the UK. With suitable measures in place, it is likely that the objective of minimising emissions, encouraging adaptability, encouraging the use of low carbon technology and increasing the proportion of renewable energy could be met.

3.9.5 Climate change resilience

The design of the GDF will also need to be resilient to the potential effects of climate change, such as increased flooding or extreme weather events. As part of the consent for the GDF, RWM will be required to demonstrate that it is protected from potential external hazards arising from natural processes, including those linked to climate change.

3.10 Noise and vibration

Box 9. Environmental objective

Minimise noise and vibration effects at sensitive receptors as far as is reasonably practicable. Seek to enhance existing conditions, where possible.

3.10.1 Summary of baseline

'Noise' in its broadest sense can be defined as 'unwanted sound', which typically arises from industrial, domestic, construction or transport-related sources. Noise receptors include residential property, schools, hospitals, care homes, places of worship, sensitive species of wildlife and areas designated as important for tranquillity. Noise effects are dependent on many factors, including the number of receptors affected and their proximity to the source of noise. The fewer the receptors, the less significant the overall effect will be although baseline levels are likely to be low or very low in remote areas and hence the effects of noise may be considerable at a few receptors. Rural tranquillity and recreational value are also at risk from medium to high levels of noise.

The UK is a densely populated country, but the population is very unevenly distributed. The population is mainly concentrated around the main urban centres with the rest of the country being much more sparsely populated. Baseline noise levels will vary depending upon the proximity of significant noise sources within the local environment. Significant noise sources would include motorways and trunk roads, mainline railways, airports and industry.

[3] This conclusion is based on a modelling assumption that all backfilling would occur during this phase.

Vibration propagates either through the ground or the air to adjacent buildings and people. However, the latter is usually quite limited in its occurrence. There is no evidence that airborne vibration can cause even minor damage to buildings, but it can be a source of annoyance, causing vibrations or rattling of doors, windows or, in extreme circumstances, floors. Baseline vibration levels are generally very low across the country and are generally below levels of perception.

3.10.2 Typical generic effects

In generic terms, noise can have the following effects:

- it can cause annoyance or changes in behaviour and attitude to people in their homes and gardens
- it can reduce amenity in public open spaces or recreational areas
- it can also affect people in other sensitive locations such as care homes, hospitals, schools and places of worship
- wildlife can also be affected by noise; however, noise disturbance is taken into account in the assessment of effects on wildlife under Section 3.6 and such effects are not therefore considered again in this section

Guidance published by the former Highways Agency (now Highways England) for the assessment of airborne vibration indicates that it is only likely to give rise to significant effects within 40 metres of a carriageway. Ground-borne vibration can be produced by seismic survey techniques, percussive piling or compaction works, blasting and some near-surface mining works. Such vibration can be a source of building damage and annoyance if property and local residents are located in close proximity.

It is not possible at this stage to predict actual noise or vibration levels for any part of the life cycle of the GDF without more detailed site-specific design and construction programme information, or to predict effects in detail without knowing the location of the GDF and the number and proximity of receptors and local topographic conditions. However, a broad summary of the likely types of effects is provided below.

The objective is likely to be achievable using standard mitigation methods. The ability to provide any enhancement to existing conditions depends largely on the nature of the existing conditions and the feasibility of reducing any existing noise sources.

3.10.3 Summary of noise and vibration effects during the siting process

Potential sources of noise or vibration during the site selection process of the GDF could include the following.

- Light aircraft involved in surveys during the site selection process – these will be very transient, and it is therefore unlikely that they will result in significant effects.
- Seismic surveys during the site selection process could generate both noise and low-amplitude vibration. Again, these will be of short duration and very transient and it is not likely that they will result in significant effects.
- Borehole site investigation surveys during the site selection process could generate noise over periods of several months at any one location. However, these will again be transitory and could be mitigated to ensure that no significant effects were likely.

3.10.4 Summary of noise and vibration effects during initial construction phase

During construction of the surface facilities and underground workings, there could be noise and vibration generated from excavation and piling works potentially including blasting, earth moving equipment, construction plant, construction vehicles, ventilation systems and access for the underground workings.

Vibration effects could, in principle, occur during the construction of the surface facilities if any piling works are required or during the early (near-surface) stages of the excavation of the underground workings. However, it is most likely that any such works would take place well within the boundary of the GDF site and that, as a consequence, no receptors would be sufficiently close to experience significant vibration effects. The exception to this is the potential need for blasting if the GDF site is located in a hard rock area.

Construction noise levels are likely to be highest during this initial construction phase as a result of construction of the surface facilities. Mitigation will include consideration of suitable screening for the GDF site, integrated with the landscape strategy and security requirements.

3.10.5 Summary of noise and vibration effects during ongoing construction and operation phase

Noise levels during the ongoing construction and operation phase are likely to be lower than during the initial construction phase, and will principally derive from:

- delivery of radioactive waste for disposal in the GDF (mainly by rail, potentially with a small number of daily deliveries by road)
- delivery of backfill material, where required (by a combination of rail and road transport)
- removal and surface handling of excavated rock spoil from ongoing underground excavations and management of surface mounds (on-site works, plus a combination of rail and road transport)
- ventilation, power and access systems for the underground workings

Vibration effects are less likely to occur during operation, as surface works will be limited (primarily related to movement of excavated materials) and ongoing excavation operations will be too deep to significantly affect receptors at the surface.

3.10.6 Summary of effects during and after closure

Activities during this phase would include some activities similar in nature to the initial construction phase. However, overall noise levels are likely to be lower than during the initial construction phase. Noise and vibration sources could include demolition activities, the use of earth moving equipment and vehicles. Depending on the agreed end use for the site, some mounds may be removed at this time. It is likely that any such works would take place well within the boundary of the GDF site and that, as a consequence, no receptors would be sufficiently close to experience significant vibration effects.

3.10.7 Performance against environmental objective

There is some potential for negative effects in relation to the noise environment associated with the GDF and, in particular, during the initial construction phase. Some generation of noise associated with activities at the site and the associated traffic movements will be unavoidable. The significance of such effects and the degree of compliance with the objective will be dependent on the actual environment and, in particular, the proximity to

receptors. In the event that the GDF and affected transport routes are not located in close proximity to receptors, such as residents, users of recreational facilities and noise-sensitive species, the significance of effects resulting from noise generation may be limited.

The nature and type of mitigation will be determined by nature of the receiving environment, as will the extent to which any negative effects can be fully mitigated. However, effective measures are available to control, for example, construction noise through use of quieter equipment or through screening. The degree to which the objective can be met will determined by site-specific conditions. Therefore, at this stage the performance against the objective has not been scored.

3.11 Land use and community

Box 10. Environmental objective

Minimise consumption of, and reduce damage to, undeveloped land and agricultural holdings through re-use of previously developed land and existing buildings where possible. Protect and enhance recreational resources, land and facilities valued by the local community.

3.11.1 Summary of baseline

Over 65% of the UK land area is agricultural, the remainder being forestry (13%), urban/ developed (11.7%) and other uses (9.6%). However, 81% of the population is concentrated in only 21% of the land area, particularly concentrated around the main urban centres.

Agricultural land is classified into five grades, based on its quality and versatility. Grades 1, 2 and 3a (Grade 3 land is subdivided into Grades 3a and 3b) are defined as the 'best and most versatile' land and national planning policy guidelines, such as the National Planning Policy Framework [25] in England, define a preference for development outside 'best and most versatile' land.

Community effects can include changes in the availability of, or demand for, recreational resources (such as rights of way or common land) and local facilities. Effects on population and demand for local services are set out within the Generic Socio-economic Assessment [8].

3.11.2 Summary of effects during siting process

Land use effects during the siting process could arise from the following:

- temporary land-take for drilling compounds and access routes during the siting process, affecting existing site users
- temporary loss or severance of agricultural land or loss of access and disruption of agricultural practices as a result of temporary land-take
- damage to agricultural land quality and soils, drainage or water-supply systems as a result of temporary land-take

However, all the above will be short term in nature (generally around 6 months per borehole) and will generally be subject to effective mitigation and reinstatement following the period of temporary disturbance. In the event that recreational or other community resources are affected by borehole drilling, suitable mitigation is likely to be possible (such as provision of alternative routes for rights of way for the duration of the works).

3.11.3 Summary of effects during initial construction phase

After a site for the GDF has been selected, depending on its location, the following land use effects could in principle arise:

- long term/permanent land-take for the site of the GDF and any new transport links
- loss or severance of recreational or community land
- loss or severance of agricultural land or loss of access and disruption of agricultural practices
- loss of agricultural soils and interruption of existing drainage or water-supply systems

Given the scale of the GDF, there will be a significant change to the existing land use. The degree to which this is significant will be dependent on the nature of the existing land use. If the selected site is currently in agricultural use, there is potential for negative effects in terms of the operation of individual farm holdings and their viability. Depending on the quality of any agricultural land present, effects in terms of the loss of such land have the potential to be significant.

Effects on recreational and community land are likely to be site-specific. However, it is anticipated that such effects could in most cases be mitigated through replacement of facilities affected. Opportunities for enhancement with respect to local facilities and recreational routes will be explored to suit the needs of the host community. The UK Government and devolved administrations have committed to provide additional investment to the community that hosts the GDF. The White Paper on geological disposal [2] states that these measures will be tailored to bring long term benefits tailored to the specific site selected and could include, for example, improved recreational facilities.

Opportunities may exist to re-use and enhance previously developed land and existing buildings. However, it is acknowledged that the objective to minimise consumption of, and reduce damage to, undeveloped land and agricultural holdings through re-use of previously developed land and existing buildings could be a challenge given the scale of the GDF.

3.11.4 Summary of effects during ongoing construction and operation phase

Following completion of the initial construction phase, it is unlikely that additional loss of land would occur (as the extent of the site will have been defined and removed from its previous use as part of the initial construction phase). The effects during this phase will therefore relate to ongoing activity at the site and opportunities for continued enhancement to local facilities and resources.

Wider socio-economic effects are considered in the generic Socio-economic Assessment [8]. This assessment identifies the potential for socio-economic benefits associated with employment and economic effects.

3.11.5 Summary of effects during and after closure

During the closure phase, there will be ongoing activity within the site but additional land take is not anticipated at this stage. The developer, in consultation with the local community, could specify the end state for the site (including the preferred land use) following completion of site closure. Depending on the final land use, the post-closure phase may offer some potential for future beneficial use of the land by the community or for agricultural purposes.

3.11.6 Performance against environmental objective

There is some potential for negative effects on land use and community associated with the siting process, primarily through the drilling activities. These effects will be limited in their geographical scale and therefore effects on more sensitive land uses or facilities may be able to be avoided. In addition, effective restoration of areas affected by temporary boreholes is likely. Without mitigation, localised negative effects are likely and, therefore, the siting phase may detract from the achievement of the objective. However, restoration will ensure that such effects are temporary and unlikely to be significant.

As set out above, there is some potential for mitigation of effects arising during the siting phase, through the adoption of normal site investigation and construction techniques. In some cases, some improvement to existing conditions may be possible. Therefore, with suitable mitigation in place it is likely that the objective could be met.

Construction of the GDF will require initial land take and therefore effects on the existing land use at the site(s) will be unavoidable. In addition, construction, operational and closure activities may affect users of nearby land or community facilities. There is therefore considerable potential for negative effects on land use and community without mitigation, which would detract from the achievement of the objective.

As set out above, the initial loss of land will be unavoidable. However, there is some potential to minimise effects through the detailed siting process and considerable potential for mitigation and enhancement with respect to the provision of new or improved community resources. With suitable mitigation in place it is likely that the objective will be met and that enhancements could be delivered.

3.12 Waste

Box 11. Environmental objective

Minimise the generation of waste and promote the application and adherence to the waste management hierarchy.

The purpose of the GDF is to provide a facility for the disposal of radioactive waste. The long-term radiological impacts of the GDF are discussed in the generic Environmental Safety Case [6]. This section addresses the generic environmental effects associated with the potential creation, management and disposal of non-radiological waste as a result of developing the GDF.

3.12.1 Summary of baseline

Waste is defined as, *'any substance or object which the holder discards or intends or is required to discard'* [26]. Waste can be categorised in a number of ways, such as:

- by its source (for example domestic, commercial, industrial, agricultural)
- by its characteristics (liquid/solid/gaseous, inert, biodegradable/non-biodegradable)
- by its risks (for example hazardous, non-hazardous, explosive, radioactive)

Traditionally, a high proportion of waste in the UK was disposed of in landfill sites. This proportion has reduced over recent years following policy-led initiatives at European, national and local levels to minimise the use of landfill for environmental reasons. Policy is based around a 'waste hierarchy', as follows:

- the preferred option is the prevention of the initial generation of waste
- re-use (for example the traditional doorstep collection of milk-bottles for re-use)

- recycling (the recycling of waste materials to make something different)
- recovery (for example energy recovery through incineration)
- disposal, for example in landfill, is therefore the last resort

The disposal of waste to landfill is heavily taxed through the Landfill Tax. This has encouraged the development and uptake of alternative waste management technologies, such as recycling and composting. However, some categories of waste with no market for alternative use have no alternative management route other than landfill.

3.12.2 Summary of effects during siting process

A range of wastes will be generated during the siting process. The largest contributors will be drill cuttings (rock), drilling fluid, test waste, construction waste, office and organic canteen waste. Depending on their type, wastes may be re-used, recycled or sent to landfill. The siting process is expected to take around ten years.

Performance against environmental objective

Waste generation will occur over a relatively short period (associated with borehole drilling) and the effects of this waste are not likely to be significant.

Good practice waste minimisation and management practices, in line with published guidelines, will be implemented (for example through a site waste management plan) and opportunities for beneficial re-use of drilling cuttings (for example re-use as secondary aggregate) will be explored. A site waste management plan will be developed and periodically reviewed, updated and implemented throughout the life cycle of the GDF. Therefore, with suitable mitigation in place it is likely that the objective could be met.

3.12.3 Summary of effects during initial construction phase

The initial construction of the GDF and associated infrastructure (access roads, railhead) will generate large amounts of construction wastes. The types of wastes generated will be similar for the different host rock types. However, the quantities of excavated rock arising from underground excavations will vary depending on the host rock type.

Estimates suggest that the overall volume of rock to be excavated during the initial construction phase will be greatest for a higher strength rock site and least for an evaporite rock site. Higher strength rock and lower strength sedimentary rock are both suitable for construction of mounds on the surface of the site. The higher strength rock could also be used in backfilling operations. The use of the rock for construction of mounds, where possible, will avoid the rock being exported from the site as waste and will reduce the need to transport material off-site. However, if the capacity of the site is reached in terms of available mound areas for excavated higher strength and lower strength rock, excess material may need to be exported from the site.

Evaporite rock is not likely to be suitable for the construction of surface mounds, unless within a covered building. It is therefore anticipated that the majority of this excavated rock would need to be exported from the site. Although evaporite rock would produce the most surplus excavated rock, which potentially could have significant effects on existing waste management infrastructure, it may be of commercial value (particularly halite) and has the highest potential for beneficial re-use. It is considered possible that alternative uses could be identified for this type of rock. Lower strength sedimentary rock is of lesser commercial value and, as a result, any excess rock, where it cannot be accommodated on the site, is more likely to fall within the waste management regime.

Targets will be set to divert a proportion of waste from landfill, focusing on the main waste types. Quantities and types of waste will be monitored, with performance assessed against targets.

Performance against environmental objective

Waste generation will occur throughout the construction period and for some rock types some export of rock from the site may be required. Without mitigation, significant effects are likely and, therefore, may detract from the achievement of the objective.

As set out above, waste minimisation and management practices, in line with published guidelines, will be implemented and opportunities for beneficial reuse of materials will be explored. A site waste management plan will be developed and periodically reviewed, updated and implemented throughout the life cycle of the GDF. Therefore, with suitable mitigation in place it is likely that the objective could be met.

3.12.4 Summary of effects during the ongoing construction and operation phases

During this phase, construction activities would continue. These would generate similar types of waste to those set out above for the initial construction phase but the levels are likely to be lower. Wastes associated with the operation of the site, including office and catering wastes are likely to continue at this stage. As for the initial construction phase, targets will be set to divert a proportion of waste from landfill, focusing on the main waste types (including operational wastes). Quantities and types of waste will be monitored, with performance assessed against targets.

Performance against environmental objective

As for the initial construction phase, waste generation will occur throughout this period and will be able to be managed through a site waste management plan. In addition, it should be noted that the key reason for construction and operation of the GDF is to ensure effective management of radioactive waste. In this respect, the overall effect would be beneficial.

3.12.5 Summary of effects during and after closure

During closure, the principal source of waste generation will be the decommissioning and demolition of surface facilities. A pre-demolition audit will be undertaken to identify materials for re-use and recycling. As far as possible (taking into account the safety requirements, long timeframes and difficulties in predicting the future), the potential for materials to be recycled will be considered as part of the construction phase. This will form part of an integrated waste management strategy, aiming to divert waste from landfill and to make the most of the opportunities and technologies available at that time. This could include supply of ‘waste’ materials from the GDF site to other construction sites elsewhere.

Performance against environmental objective

Some waste generation will continue to occur throughout the closure period. Without mitigation, some effects are likely and, therefore, may detract from the achievement of the objective.

Waste minimisation and management practices established during the lifetime of the GDF could continue to be implemented in relation to waste generated during backfilling. Therefore, with suitable mitigation in place it is likely that the objective could be met.

Overall, the objective is likely to be obtainable through standard and well established mitigation and monitoring measures. Monitoring measures will be implemented together

with appropriate plans of action in the event that targets are not met. Opportunities may also exist to minimise the generation of waste and promote the application of and adherence to the waste management hierarchy at a local level through additional community investment.

3.13 Resource use, utilities and services

Box 12. Environmental objective

Encourage and promote the efficient use of resources (materials, aggregates, metal).

3.13.1 Summary of baseline

The UK is, relatively speaking, a resource-rich country. However, the distribution of resources is uneven, due to variations in geology, climate, transport networks and industrial development/history. In addition, for some resources, the UK is dependent on imports, either because they are not available in the UK or are not economic to exploit. For instance, bentonite is an internationally traded commodity. The UK is not a primary producer and it imports much more than it exports. While UK exports of iron and steel can greatly exceed imports, this is not necessarily the case for all types of steel and some specialist alloys are primarily imported.

3.13.2 Summary of effects throughout the life cycle of the GDF

The GDF will consume large quantities of materials throughout its construction, operation and closure phases. As the types of effects are similar throughout the phases of the GDF, this section considers the effects throughout the lifecycle of the GDF. However, it should be noted that the objective relates not to the avoidance of resource use but the efficient use of resources, so that requirements are kept to the minimum actually needed.

Examples of common materials likely to be required in large quantities during the lifetime of the GDF will include:

- steel and steel reinforcement
- rockbolts
- brickwork/blockwork
- cladding
- concrete, shotcrete, cement and other general construction materials
- concrete, aggregate and pavement (tarmac and asphalt)
- explosives for blasting
- bentonite
- crushed rock
- backfill[4]
- cementitious grout
- magnesium oxide (potentially, in evaporite rock only)

[4] 'Nirex Reference Vault Backfill' – a specified mixture of Portland cement, hydrated lime, limestone flour and water, likely to be used for backfilling the Intermediate Level Waste and Low Level Waste vaults in the GDF if it is located in a higher strength rock or lower strength sedimentary rock site.

- sand

In addition to physical materials, the GDF will require other resources, utilities and services, including:

- temporary electricity and water supplies and communication systems for the borehole drilling sites during the siting process
- electricity and water supplies and communication systems for both the surface site and the underground workings during construction and operation of the GDF
- ventilation systems for the underground workings (including a large chimney or discharge stack)
- waste water management and treatment systems for both the surface site and underground workings
- heating and lighting

It is assumed that most energy demand will be met by connection to the National Grid, with diesel generators for temporary use and backup provision.

RWM has a sustainable design objective to maximise the proportion of the GDF's annual energy demand met by renewable energy generation (taking into account technical feasibility, safety and cost issues). While this objective may be met (in whole or in part) by renewable energy supplied through the National Grid, it is anticipated that a proportion could be delivered by on-site renewable generation.

Performance against environmental objective

The construction, operation and closure of the GDF will require the use of resources and, to some extent, this cannot be avoided. The objective seeks to minimise such effects.

Mitigation is likely to be required to manage effects on natural resources. The objective is likely to be achievable through efficiencies built in to the design of the GDF, on site renewable energy production, efficient use of materials, use of more durable materials/materials that can be recycled after use, materials with a lower impact in terms of extraction, treatment, processing, transport and materials with recycled content.

3.14 Summary of effects by GDF life cycle phase

Table 3.1 below summarises the assessment findings presented in this section and set out in more detail in Appendix B. At this generic stage of assessment it is difficult to identify in detail the mitigation, monitoring and enhancement measures that would be required to address negative effects or, in many cases, how effective they might be. The assessment therefore reflects the potential effects of the GDF in the absence of mitigation. It is likely that many negative effects would be significantly reduced, and in some cases positive effects created, through the effective application of mitigation, monitoring and enhancement works.

Table 3 Summary of qualitative assessment of unmitigated effects by GDF life cycle phase

Environmental theme	Siting process	Initial construction and underground based investigation	Ongoing construction and operation	Closure
Landscape and visual	N	- -	-	N
Cultural heritage	X	X	X	X
Geology and soils	-	-	-	-
Water	-	-	-	N
Biodiversity, flora and fauna	X	X	X	X
Traffic and transport	N	- / - -	- / - -	-
Air quality	N	- / - -	- / - -	N
Climate change	N	- / - -	- / - -	-
Noise and vibration	X	X	X	X
Land use	-	- / - -	-	X
Waste	-	- -	- -	-
Resource use, utilities and services	-	-	-	-

Key to the assessment of impact	X Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

Note that where more than one score is provided, this represents a range of scores (for example, minor to major negative). This approach has been utilised where adverse effects are likely (before mitigation) but the significance of effect would depend on site-specific factors

4 Conclusions

This report seeks to present a comprehensive picture of the potential non-radiological environmental effects of siting, constructing, operating and closing the GDF to the extent that this can be assessed at the current generic stage of the geological disposal project. The potential radiological impacts of a geological disposal facility are addressed in the generic Environmental Safety Case [6].

This generic assessment is intended to inform the early stages of the siting process for the GDF. At later stages of the siting process, more detailed, location-specific assessment work will be carried out and this will inform the eventual selection of a preferred site. This will include statutory assessments such as EIAs supporting development consent order applications. It is noted that this generic assessment focuses on the unmitigated effects of the GDF, as mitigation proposals will be developed on a site-specific basis. Therefore, with mitigation and enhancement in place, adverse effects are expected to be lower than assessed in this report and some beneficial effects are likely.

Key conclusions arising from the generic assessment are set out below.

4.1 Environmental effects

Those themes under which significant environmental effects are thought most likely are landscape (including townscape), visual amenity and waste. The surface facilities are likely to affect the character of the local landscape and local views. Excavation of the underground facilities will generate significant volumes of rock spoil. In addition, there is some potential for significant air quality effects related to transport movements, depending on the balance between road and rail transport in the final proposals for the GDF and on site-specific factors (such as the nature of the local road network and the details of the mitigation/enhancement measures proposed). There is also some potential for significant effects in relation to climate change and land use.

Potential negative effects have also been identified under other themes (geology and soils; water; resource use, utilities and services). It is likely that such impacts could be effectively mitigated through well-established control measures and that, in some cases, opportunities will be available to provide related benefits.

For three themes – cultural heritage; biodiversity; and noise and vibration – potential effects were considered too dependent on site-specific information to enable a credible assessment at this generic stage. There are potential negative effects under these themes that may arise from development of the GDF, but at this generic stage the likelihood that an impact will occur and its potential significance cannot be predicted.

For each theme, consideration has been given to the potential for mitigation and enhancement. At this stage, generic measures have been identified that will contribute towards meeting the environmental objectives. In some cases, positive effects are likely with such measures in place.

4.2 Life cycle of the GDF

Potentially significant effects will be associated primarily with the initial construction phase, with some potential for such effects to continue (under some themes) into the operational phase.

The scale of works proposed during the siting process is much smaller and such works will be temporary and relatively short term, such that no significant effects have been identified.

Compared to construction and operation, the scale of activity is likely to be reduced in the closure phase. No new significant effects have been identified during this phase.

4.3 Host rock types

For the majority of the themes, the evidence available from the assessment does not permit a clear conclusion as to whether the nature of the host rock will have a significant influence on the nature of environmental effects, as much is dependent on the location of the GDF as well as the rock type.

However, it is noted that the principal influence on the amount of excavated rock spoil that may have to be removed from the site and the amount of material that may have to be brought to the site for backfilling is the total excavated volume of the GDF. Estimates suggest that the overall volume of rock to be excavated will be greatest for a higher strength rock site and least for an evaporite rock site.

In principle, the illustrative designs for the GDF aim to maximise the retention of excavated material on site in the form of temporary or permanent screening / storage mounds around the surface facilities. The ability to store rock on site would minimise the amount of material to be exported from the site, whilst re-use of stored rock from excavations during the backfilling process would minimise the amount of material to be brought to the site for this purpose.

For the evaporite rock design, only excavated material arising from initial site clearance and construction of surface facilities (and possibly shaft construction) is likely to be suitable for storage on site. Most of the spoil arising from underground construction is assumed to be unsuitable for the construction of mounds, due to its solubility and the potential environmental effects of saline leachate. Such spoil would have to be transported off-site.

These differences in rock type will influence the nature and scale of effects under some environmental themes, notably transport, but also landscape, climate change, waste and resource use.

4.4 Key sources of potential effects

For environmental receptors located above ground in the vicinity of the GDF, the key sources of potential effects are anticipated to be the initial construction of the surface site and associated transport infrastructure, and spoil management associated with excavation of the underground facilities. It is the initial construction works that will cause the main effects on landscape / townscape, heritage, biodiversity, water and land use, whilst some effects under these themes are also expected to continue during the operational phase.

Underground construction, emplacement of waste and backfilling have potential effects in terms of transport (and associated environmental effects), climate change, waste (notably rock spoil) generation and resource requirements.

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Glossary

A glossary of terms specific to the generic DSSC can be found in the Technical Background.

Appendix A – Baseline Evidence

Table A1 provides a generic overview of baseline information that has informed and been taken into consideration during the assessment. More detailed and location-specific information will be available as volunteer communities come forward and, at a later stage of the siting process, as specific potential sites are identified.

Table A1 Baseline evidence

Landscape and Visual Amenity
DEFINITION: The European Landscape Convention (ELC) was signed and ratified by the UK in 2002. The ELC defines landscape as *'an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors'* (Council of Europe (2000)). Article 2 of the ELC states that *'Subject to the provisions contained in Article 15, this Convention applies to the entire territory of the Parties and covers natural, rural, urban and peri-urban areas. It includes land, inland water and marine areas. It concerns landscapes that might be considered outstanding as well as everyday or degraded landscapes'* (Council of Europe (2000)). Landscape character. Can be defined as *' a distinct and recognisable pattern of elements, or characteristics, in the landscape that make one landscape different from another, rather than better or worse'* (Natural England (2014) An Approach to Landscape Character Assessment). It is considered to be the hierarchy of the different components that interact to form a landscape; the characteristics, elements and features that interact to form distinct landscape character areas. There are several high-level groups of factors that influence landscape character, these are: Natural factors: • geology • landform • air and climate • soils • flora and fauna • cultural/social factors: • land use • settlement • enclosure Perceptual and aesthetic factors: • memories • associations • preferences • touch/feel • smells • sounds • sight

Sight:

- colour
- texture
- pattern
- form

Seascape: Landscapes with views of the coast or seas, and coasts with adjacent marine environments with cultural, historical and archaeological links with each other.

Townscape: The character and composition of the built environment including the buildings and the relationship between them, the different types of urban open space, including green spaces and the relationship between buildings and open spaces.

Landscape quality: A measure of the physical state of the landscape. It may include the extent to which typical character is represented in individual areas, the intactness of the landscape and the condition of individual elements.

Landscape value: The relative value that is attached to different landscapes by society. A landscape may be valued by different stakeholders for a whole variety of reasons.

Landscape characteristics: Those combinations of elements which are particularly important to the current character of the landscape and help to give an area its particularly distinctive sense of place.

Landscape elements: Individual parts which make up the landscape, such as, for example, trees, hedges and buildings.

Landscape features: Particularly prominent or eye-catching elements in the landscape, such as tree clumps, church towers or wooded skylines.

Visual effects: Effects on specific views and on the general visual amenity experienced by people, including light pollution – the effect of brightening the night sky, caused by artificial lighting. It includes such effects as sky glow, light trespass, and glare.

Visual amenity: The overall pleasantness of the views people enjoy of their surroundings, which provides an attractive visual setting or backdrop for the enjoyment of activities of people living, working, recreating, visiting or travelling through an area.

NATIONAL BASELINE CONTEXT:

Landscape Baseline

Designated Landscapes

Landscapes of national importance in the UK are protected as National Parks (England, Wales and Scotland) Areas of Outstanding Natural Beauty (AONB); (England, Wales and Northern Ireland) and National Scenic Areas (NSAs in Scotland. Under the National Planning Policy Framework, National Parks and AONBs have equal status in relation to planning consent and other sensitive issues.

There are 15 National Parks within the UK, 10 in England, three in Wales and two in Scotland. National Parks cover 9.3% of the land area of England, 19.9% of the land area of Wales and 7.2% of the land area in Scotland. More information can be found at www.nationalparks.gov.uk, including a map and information about individual National Parks.

There are 46 AONBS in the UK, 33 in England, four in Wales, one straddling the English/Welsh Border and eight in Northern Ireland. More information on AONBs can be found at www.landscapesforlife.org, including a map, action plans and information about each individual AONB. Scotland has an equivalent designation, NSAs. There are 40 NSAs in Scotland which cover 13% of the land area of Scotland. More information on NSAs is found at http://www.snh.gov.uk/protecting-scotlands-nature/protected-areas/national-designations/nsa/ including a map of the NSAs.

Registered Parks and Gardens are also designated landscapes and are noted in the Cultural Heritage Theme.

In addition, local authorities may designate areas of landscape for protection under their Local Development Plan policies.

Non-designated Landscapes

Landscape baseline varies greatly both from region to region and from place to place within each region. However, a generic baseline framework can be identified.

The whole landscape of the UK is divided into 'National Character Areas'. There are–159 NCAs in England, 130 in Northern Ireland and 30 in Scotland, where they are currently under review (review started 2014). The landscape of Wales has now been categorised in to areas of different aspect layers, as part of the LANDMAP project. The aspect layers are: Visual and Sensory; Landscape Habitats; Historic Landscapes; Geological Landscape; and, Cultural Landscape aspect layers. As such, LANDMAP has replaced NCAs in Wales.

Maps and profiles for each NCA/LANDMAP aspect layer are available from the relevant authorities, as follows:

https://www.gov.uk/government/publications/national-character-area-profiles-data-for-local-decision-making/national-character-area-profiles

http://landmap.ccw.gov.uk/map/Map.aspx

http://www.doeni.gov.uk/niea/landscape/country_landscape.htm

http://www.snh.gov.uk/publications-data-and-research/publications/search-the-catalogue/?q=landscape%20character%20assessment

Seascapes

An assessment of seascape character has been undertaken for Northern Ireland. This is available at the link below:

http://www.doeni.gov.uk/niea/land-home/landscape_home/seascape_character_areas.htm

Natural Resources Wales commissioned a National Seascape Character Assessment for Wales in October 2014, this is still underway. There are no plans for a similar assessment of the English seascape, although individual assessments for specific areas have been undertaken by Natural England and others. Similarly in Scotland, no overarching assessment of Scottish seascape character has been undertaken, although a capacity study for a single development type, which includes characterisation of the Scottish seascape has been published by Scottish Natural Heritage.

Townscapes

Individual townscape characterisations are undertaken by LPAs, and may not be available for all built up areas.

Visual Baseline

The visual baseline will '*establish the area in which the development may be visible, the different groups of people who may experience views of the development, the places where they will be affected and the nature of the views and visual amenity at those points*' (GLVIA3 para. 3.15).

As with landscape character, the visual baseline will vary greatly from site to site, but will include any viewpoints or panoramas of note. A Zone of Theoretical Visibility (ZTV) will be generated which will indicate where the proposed GDF will be visible from. Existing available views will be described, including visual amenity.

Landscape Value

In considering natural beauty and amenity, judgements will be based, at least in part, on the concept of landscape value (the relative value or importance that stakeholders attach to different landscapes and their reasons for valuing them) (Scottish Natural Heritage and The Countryside Agency (2002) *Landscape Character Assessment: Guidance for England and Scotland,* para. 7.22). Value includes assessing the following: Landscape quality; scenic

quality; rarity; representativeness; conservation interests; wildness; and, associations (historic, cultural or artistic). Tranquillity is also a reason for valuing a landscape.

Geological Differences

Geology at the surface is one of the determinants of landscape character. While the geology at the depth of any proposed GDF site may be very different from that at the surface, it will be related (for instance, it is unlikely that there will be higher strength rock at the surface if the geology at depth is lower strength sedimentary rock or evaporite rock, although higher strength rock at depth is very likely to be overlain by lower strength sedimentary rock), while at many potential higher strength rock sites the geology at depth may extend to the surface. The choice of a rock type will therefore influence the nature of the landscape at the GDF site.

FUTURE BASELINE CONDITIONS:

In light of the projections described in the Climate Change theme baseline section (Appendix A) and the long-term nature of the GDF, potential future baseline conditions relevant to landscape and visual resources as a result of projected climate change are:

- sea level rises/flood plains and estuaries
- changes to biodiversity (some species increase in number and range whilst others decline)

Other noteworthy and reasonably foreseeable changes and trends which could occur over the time scale associated with the GDF are:

- land management/agricultural practices
- expansion/creation of settlements and urban areas
- expansion of transport or energy infrastructure
- mining/landfill operations and restoration
- changes in landscape designations such as boundaries or creation of new areas

Cultural Heritage

DEFINITION: Cultural heritage refers to historic elements of an area that contribute to its 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. Historic seascape character can also be included in this.

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 such as Scheduled Ancient Monuments (SAM), Listed Buildings, Register of Parks and Gardens and the Register of Historic Battlefields. Sites are recommended for designation by the relevant authority (Historic England, Cadw, Historic Scotland and the Department of the Environment for Northern Ireland).

According to the 2015 GIS data set obtained from National Heritage List for England website, England contains:

- 18 World Heritage Sites
- 19,854 SAMs

- 1,634 registered parks and gardens
- 376,019 listed buildings
- 49 Registered Battlefields
- 48 Protected Wrecks

The February 2013 GIS dataset for Wales indicates there are:

- 3 World Heritage Sites
- 4180 Scheduled Monuments
- some 29963 Listed Buildings

The 2015 GIS dataset for Wales indicates there are:

- 6 World Heritage Sites
- 4,181 Scheduled Monuments
- 385 registered parks and gardens (using park boundaries)
- 58 Designated Landscapes (Historic Landscape Areas)
- some 29,965 Listed Buildings.

There are also 6 designated wrecks

The 2015 GIS dataset for Scotland indicates there are:

- 9 World Heritage Sites (although when googled there are 6)
- 8,179 SAMs
- 39 battlefields
- 383 gardens and designed landscapes
- 68,032 listed buildings

The 2015 GIS dataset for Northern Ireland indicates there are:

- 1 world heritage site
- 248 gardens
- 12,690 listed buildings
- 16,463 sites and monuments

There are no entirely natural landscapes in Britain; all have been modified by continuous human occupation and land-use over thousands of years, and therefore the traces of that human activity are evident wherever you go in the UK.

The nature of the landscape and land-use over long periods of time has a major influence on the type of archaeological and historic sites likely to be present, how densely concentrated they are likely to be and how well-preserved they are likely to be. In lower-lying, more fertile areas, older monuments are less likely to survive or to be well-preserved due to the intensity of later activity, but there is likely to be a higher density of more recent remains and historic buildings. In upland areas that are less well-populated and have remained uncultivated or rarely cultivated, much more ancient monuments are more likely to survive in relatively good condition.

Historic seascape character units (non-designated) have been defined by Historic England. These describe those historic cultural influences which shape the present seascape perceptions across all of England's marine areas and coastal land. No such characters have yet been defined in Scotland, Wales or Northern Ireland.

FUTURE BASELINE CONDITIONS:

In light of the projections described in the Climate Change theme baseline section (Appendix A) and the long-term nature of the GDF, potential future conditions relevant to cultural heritage as a result of projected climate change are:

- rising sea levels and possible increased storminess could endanger historic landscapes, structures, buildings and archaeology in coastal zones
- increased extremes of weather and risk of subsidence could pose a threat to historic buildings
- increased erosion of archaeological sites and flooding in historic settlements
- changes in hydrology that put buried archaeological remains at risk
- changes in vegetation patterns could threaten the visibility and integrity of archaeological remains and historic landscapes
- warming may make historically authentic tree planting at risk
- changes in the distribution of pests may threaten the integrity of historic buildings, collections and designated landscapes
- increased frequency and range of extreme weather could damage historic landscapes and buildings

(Ref: English Heritage (2008) Climate Change and the Historic Environment.)

Other noteworthy and reasonably foreseeable changes and trends which could occur over the time scale associated with the GDF are:

- the ongoing designation process adding more designated historic assets to the baseline
- ongoing loss of archaeological remains resulting in the remaining resources becoming more valued and important

Geology and Soils

DEFINITION: This topic considers the baseline relating to geology and soils in terms of land quality and scientific interest.

NATIONAL BASELINE CONTEXT:

Contaminated land

The UK has a substantial legacy of chemical contaminants in soil and is recorded formally within the Contaminated Land Register. Some contaminants may be present naturally, but more often they occur as a result of human industrial and domestic pollution. Such contamination is typically found in brownfield sites on former industrial land. The majority of such sites are in urban contexts, but a large number are not, particularly those associated with mining or other extractive industries, primary processing of bulk raw materials and power generation. Siting of the GDF should avoid known contaminated land unless remediation is built into the design considerations.

Geology

Geodiversity is the variety of rocks, fossils, minerals, natural processes, landforms and soils that underlie and determine the character of our landscape and environment (UK Geodiversity Action Plan, Natural England: http://www.ukgap.org.uk/

One geological site in England (the Dorset and East Devon Coast, also known as the Jurassic Coast) has been recognised as a World Heritage Site.

Geology of particular importance is protected through designation as geological Sites of Special Scientific Interest (SSSI), or at local level as Local Geological Sites (also known as Regionally Important Geological Sites, or RIGS). There are around 1,215 geological SSSIs in England and 450 in Wales (https://www.gov.uk/government/organisations/natural-england; https://naturalresources.wales/splash?orig=/)

In addition there are 7 Geoparks in the UK, namely English Riviera (Torbay, South West England), Fforest Fawr (South Wales), GeoMôn (Anglesey, Wales), Marble Arch Caves (Northern Ireland), North Pennines A.O.N.B. (Northern England), North West Highlands (Highlands of Scotland) and Shetland (Shetland Islands, Scotland) (National Commission for UNESCO).

In Northern Ireland, 'Areas of Special Scientific Interest' are equivalent to SSSIs, and geological sites are designated on the basis of the Earth Science Conservation Review. A total of 667 sites were included in the review (http://www.habitas.org.uk/escr/). There are a total of 374 Areas of Special Scientific Interest, although the majority of these will be designated for biodiversity rather than geological reasons.

FUTURE BASELINE CONDITIONS:

Although generally considered to be a topic area for which changes are long-term rather than rapid, it is acknowledged that climate change may have an impact on geology, soils and ground conditions, together with existing geological processes. Whilst this is not a topic covered by many forecasting tools, studies into the effects of geological disposal facilities do include considerable research into the geosphere and the likely stability or propensity to change of the geological environment. In relation to climate change impacts these are more likely to influence:

- subsidence
- landslides

Other long term potential geological changes can include frequency and scale of:

- seismicity
- faulting
- uplift

However, the long-term suitability of different geological formations in relation to the GDF is part of the safety case.

In terms of soil quality and ground conditions, existing land uses can contribute to creating new sources of ground contamination that may remain in the longer-term, although current policy towards remediation may result in an overall improvement.

Appendix B – Detailed Assessment

B1 Introduction

This appendix sets out the details of the generic assessment of potential effects that the GDF could have on the environment across its lifetime.

The tables within this appendix set out the extent to which the planned activities during each phase of the life cycle of the GDF may contribute towards the environmental objectives relevant to each environmental theme. The colour coding and symbols in the 'Score' column represent an assessment score in accordance with the methodology described in Section 2.4 and Table 2.

It should be noted that the assessment scores presented in these tables largely reflect unmitigated effects. The right-hand column, describing potential mitigation measures, identifies in many cases measures that may or may not be applicable, or may be applicable and effective to greatly varying degrees, depending on local circumstances at specific sites. At a generic level it is considered that there is too much uncertainty to enable a re-assessment taking mitigation into account, and only the un-mitigated assessment scores are presented.

B2 Landscape and visual effects

Table B2 Landscape and visual effects

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Maintain and enhance the quality and character of the landscape, seascape and townscape and maintain and enhance existing views. Seek to minimise any adverse effects on quality, character, views and light pollution.		
Siting process	Borehole drilling has the potential to create the following negative effects, although the realisation of this potential would be dependent on the detailed planning of the works and on the characteristics of the locality: • Fragmentation/loss of landscape features affecting landscape character, particularly as a result of the construction of access routes • Introduction of new elements into existing views would have negative visual effects, for example erection of the drilling rigs • Light pollution effects from 24-hour lighting Drilling works would last approximately six months at any single borehole location and it is expected that two drilling rigs would operate simultaneously within a target area of 10 km^2. Some equipment would be left in place for monitoring purposes. In general, these effects would be temporary and there is high potential for mitigation through reinstatement of the land and of any trees or hedgerows that have been lost or damaged.	N	**Mitigation** • Effective engagement with communities to identify valued features • Avoidance of valued features • Design to minimise negative effects on visual amenity • Avoid/minimise lighting where possible consistent with security • Plan work to facilitate site restoration, including aftercare • Follow good practice in the protection, management and restoration of soils **Monitoring** • Development and implementation of an Environmental Management Plan **Enhancement** • Opportunities may exist through the restoration of the borehole drilling locations

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	The works are therefore considered to contribute negatively towards the objective in the short term, but in the medium to long term the effect would be neutral.		for landscape and visual improvements compared to the baseline condition
Initial construction and underground based investigation	Surface construction activities have the potential to result in the following negative effects: • Fragmentation or loss of key landscape elements and potentially significant change to local landscape character • Potentially significant visual intrusion • Introduction of new infrastructure, including rail and/or road infrastructure The introduction of new visual elements, removal of surplus excavated rock from site and 24-hour lighting could all negatively affect landscape character and visual amenity. The surface footprint for hard rock geology is expected to be around 1.4 square kilometres based on generic illustrative designs. It is anticipated that none of the evaporite rock would be used for mounds. Therefore, mounds would be constructed from surface material and, if necessary, imported material. For lower strength sedimentary rock, material in the mounds would be unsuitable for backfilling, and would probably therefore remain undisturbed for the lifetime of the GDF. Surface mounds can have two effects:	- -	**Mitigation** In addition to the continuation of the above, where appropriate: • Consideration of landscape/ visual effects in site selection and design • Minimise footprint and adjust layout of surface facilities and infrastructure • Potentially establish temporary screening at outset and replace with longer-term landscape mounding and planting to screen views of site and integrate into landscape • Establish planting as early as possible to maximise its effectiveness. Use locally-sourced native tree and shrub species • Design landscape mitigation in character with local landscape • Consider both on and off site landscape and planting works • Consider landscape works in an integrated way with ecology/biodiversity mitigation **Monitoring** • Development and implementation of an

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	• They help to screen views of visually intrusive features and provide a raised surface for tree and shrub planting to further enhance visual screening. Sufficient height is required to provide effective screening, and sufficient width to provide a suitable surface for planting. • Excessively high mounds can be visually intrusive in their own right (although usually less so than the features they screen), unless carefully designed and effectively integrated into the landscape. Construction of the GDF will have greater potential landscape and visual effects than surface-based site investigations. However, at this stage no site has been selected and therefore the significance of any negative effects is currently uncertain as the significance will be dependent on the host environment.		Environmental Management Plan. To include monitoring of success of establishment for landscape works for example planting. **Enhancement** • Opportunities may exist to improve the landscape and visual resources local to the GDF for example creation of new landscape elements or improved access to valued landscapes
Ongoing construction and operations – at the GDF	Surface facilities/infrastructure could have the following long-term effects: • Visual intrusion and effect on landscape character due to surface facilities, ongoing storage and movement of excavated rock as underground excavation would continue • Negative visual effects due to lighting for operational, safety and security purposes • Surface mounds, visual screening and any other	-	**Mitigation** In addition to the continuation of the above, where appropriate: • Operational phase environmental management plan(s) • Periodic review and update of environmental management plan(s) throughout operations • Landscape/visual mitigation and enhancements to be progressed and a long-

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	mitigation would have become more established, reducing landscape and visual effects • As no improvements to the rail/road infrastructure are anticipated outside the construction phase no new negative effects are envisaged in relation to these features On a higher strength rock site, some rock would be suitable for use in backfilling during the operational period, whereas this would not occur on other host rock types. This may give rise to additional visual intrusion due to the presence of mounds that are periodically disturbed, replenished and depleted.		term maintenance plan established and implemented • Preserve visual integrity of outermost mounds providing visual screening, using mounds further into the interior for rock storage/handling • Reduce lighting of outer perimeter fence as far as possible while meeting security requirements. Careful design of lighting of security fences and lighting of active areas to minimise light spillage • Mounds to be designed to provide landscape mitigation and visual screening; where appropriate their visual screening effect could be enhanced by establishing tree and shrub planting on the mounds, if suitable depths of subsoil and topsoil are used in the formation of the mounds, which will also help to soften the impact of the mounds themselves. • Consider landscape works in an integrated way with ecology/biodiversity mitigation **Monitoring** • Development and implementation of an Environmental Management Plan. To include monitoring of success of

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
			establishment for landscape works for example planting. **Enhancement** • Continued management of improvements put in place during initial construction phase. Ongoing review of success of landscape scheme and identification of any further opportunities to improve the landscape local to the GDF.
Closure	Potential negative visual effects could occur during the following activities: • Surface support for backfilling, sealing and closure of underground facilities • Closure, decommissioning and demolition of surface facilities These would be of a similar, or lesser, scale and nature as above and it is assumed any visual screening and enhancements would be well established, reducing potential effects. Post-closure, the site would be restored to an end-state agreed with the local community. Visually intrusive features associated with the GDF will have been removed, while there is the potential for some or all of the beneficial features, such as the landscape mitigation established during the lifetime of the GDF, to be left in place. A proportion of the surface mounds may be left in	N	**Mitigation** In addition to the continuation of the above, where appropriate: • Appropriately designed site restoration, with input from local stakeholders, taking into account the landscape context at the time of closure • Where appropriate and possible, restoration of any landscape/habitat lost as a result of the GDF on a like-for-like or better basis, with aftercare provision • Where appropriate, retention of mature landscape features established as part of landscape and visual mitigation during construction or operation **Monitoring**

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	place, where the rock of which they are formed is not required for backfilling. By this stage the surface mounds would support mature tree planting, so their retention would be beneficial. However, on a higher strength rock site it is likely that some of the mounds would be removed to enable the use of the rock for backfilling. It is recommended that such mounds are not used as a key part of the landscape strategy or used for substantial planting.		• Development and implementation of an Environmental Management Plan **Enhancement** • Opportunities may exist to improve the landscape through the restoration of the GDF and removal of infrastructure during closure. End state to be agreed nearer the time with the host community.

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

B2.1 Future baseline conditions

Potential future baseline conditions relevant to landscape and visual resources are described in Appendix A for this theme. These potential future conditions are too complex/uncertain to allow an assessment score to be given at this stage.

Note: this topic is too dependent on site-specific information to allow an informed assessment to take place in line with the scoring system at this generic stage. The scores throughout this table are therefore given as 'not scored'.

B3 Cultural heritage

Table B3 Cultural heritage

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Minimise detrimental effects on heritage assets and their settings. Seek to enhance the recording, conservation and preservation of assets and their settings.		
Siting process	Construction of borehole drilling pads, access roads and support infrastructure, could result in the direct loss or damage to: • Visible above ground cultural historic or archaeological features and historic landscapes • Buried archaeological remains • Historic buildings and monuments Potential for archaeology below a depth of 1-3 metres is considered to be limited, except in defined areas (such as mining areas). Therefore, the greatest effects would be seen during construction works, shallow surface investigations such as trial pitting and trenching, and shallow borehole drilling. Although they would be caused by temporary works, any such effects would be permanent in nature. In addition to the above, the surveys could cause temporary effects on the setting of historic buildings, ancient monuments, archaeological features visible above ground and historic landscapes.	X	**Mitigation** Avoid designated heritage assets or undesignated assets of equivalent value as far as practicable. Avoid other heritage assets where possible or take steps to minimise negative effects. Site the works sensitively with regard to the setting of heritage assets. Design methodology for compounds and access roads to minimise ground disturbance. Conduct archaeological watching brief. Liaise with appropriate archaeological curator/ other authorities re other mitigation needs. **Monitoring** Liaise with appropriate authorities regarding monitoring of compliance with agreed mitigation. **Enhancement** Opportunities may exist local to the borehole drilling locations to enhance the recording, conservation and preservation of heritage assets and their setting/s

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
			Opportunities may exist through the restoration of the borehole drilling locations for improved interpretation, access or setting of local historic assets.
Initial construction and underground based investigation	The majority of any archaeological features, historic buildings and landscapes and other cultural heritage features are likely to be visible above ground or within 1-3 metres below it. Any such features could be affected by: • Surface construction activities resulting in direct loss of or damage • Construction activities negatively affecting the setting and amenity of features and landscapes • Contamination, ground consolidation, or hydrological changes • If dewatering is required during construction and this affects surface deposits, this could significantly affect any peatlands or other palaeoenvironmental remains if present Significance of difference in potential effects on cultural heritage features: • As evaporite rock yields a smaller volume of excavated rock for site storage, surface disturbance could be less for evaporite rock	X	**Mitigation** Site selection to be conducted in the light of detailed knowledge of local heritage gained through EIA. Avoid Scheduled Monuments, Listed Buildings or other designated heritage assets or undesignated assets of equivalent value where practicable. Select site and design GDF with consideration of potential effects on the setting of historic buildings and other heritage assets. Seek to maintain the integrity of historic landscapes where practicable. Consider the setting of heritage assets, integrity of historic landscapes in design of landscaping works. Seek opportunities to maintain and enhance access to heritage assets where appropriate. Liaison with local community regarding cultural environments. **Monitoring** Liaise with appropriate authorities regarding monitoring of compliance with agreed mitigation. **Enhancement**

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
			Opportunities may exist to improve access to heritage assets and their interpretation Opportunities may exist to enhance the recording, conservation and preservation of heritage assets and their settings.
Ongoing construction and operation	No new direct physical effects on cultural heritage within the GDF site would occur during the operation phase. Any effects on the setting of historic buildings or monuments in the vicinity of the GDF will continue throughout the operation phase, although their significance may be reduced as mitigation works mature.	X	**Mitigation** In addition to the continuation of the above, where appropriate: • Seek opportunities to enhance access to heritage assets as a recreational or educational resource where appropriate • Ongoing maintenance of any mitigation works relating to the setting of nearby heritage assets **Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation. Monitor success of any mitigation put in place. **Enhancement** Opportunities may exist to improve access to heritage assets and their interpretation. Opportunities may exist to enhance the recording, conservation and preservation of heritage assets and their settings.
Closure	Surface activities associated with backfilling, sealing and closure, and decommissioning of the surface facilities and infrastructure could affect the setting and	X	**Mitigation** In addition to the continuation of the above,

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	amenity of any historic buildings or other historic/ archaeological monuments and landscapes in the vicinity of the GDF. Effects would be of a similar, or lesser, scale and nature as above and any visual screening and enhancements would be well established. No further significant effects are anticipated. Again, site-specific assessment would be necessary to determine effects on cultural heritage.		where appropriate: • Establish 'legacy' maintenance arrangements for heritage assets on site or in vicinity and for any access arrangements • Ensure closure does not compromise setting of any nearby heritage assets **Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation. **Enhancement** Opportunities may exist to improve the setting of, access to and interpretation of heritage assets through the restoration of the GDF and associated infrastructure. Opportunities may exist to enhance the recording, conservation and preservation of heritage assets and their settings.

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

B3.1 Future baseline conditions

Potential future baseline conditions relevant to cultural heritage are described in Appendix A for this theme. These potential future conditions may detract from the achievement of the environmental objective.

B4 Geology and soils

Table B4 Geology and soils

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Prevent and reduce contamination and safeguard soil quality and quantity, together with features of geological interest. Where land is affected by contamination, remediate to a condition suitable for use.		
Siting process	Effects of borehole drilling potentially include: • Temporary removal of topsoil and subsoil during the construction of borehole drilling pads, support infrastructure and access roads • Soil quality may be reduced for a period following reinstatement • Low level contamination to soils (for example silty water, drill fluid/oil spills) • Disturbance/remobilisation of existing contaminants (more likely on brownfield than greenfield sites) • Between 75 and 100m^3 of rock per year would be removed for testing and analysis. Once no longer required, it would be disposed of to landfill[5]	-	**Mitigation** Design site investigation works to avoid designated sites (SSSIs and RIGS) unless no other suitable site is practicable. Strip topsoil ahead of works. All soil handling, storage and management to be in suitable (dry) conditions and according to relevant guidelines and an appropriate management plan. Store different soil types separately and minimise duration of storage. Avoid soil compaction on site and while in storage. Establish grass cover on soil mounds. Seek opportunities for beneficial re-use of drill cuttings to avoid disposal as waste, where practicable in light of commercial, technical and environmental factors.

[5] Shallow ground investigations may be required on brownfield sites. If so, there is the potential for small quantities of contaminated material to be encountered that may need to be disposed of as hazardous waste. This would not affect the majority of the volume of the drill cuttings, and is unlikely to occur on greenfield sites.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	• Drilling could affect recognised important geological sites (for example SSSI or RIGS) if boreholes were located in such sites. The potential for significant effects cannot be considered fully at the generic stage but could in principle be avoided by the siting of boreholes.		**Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation. **Enhancement** Knowledge of the geology and ground conditions at each borehole drilling location will improve through the results of the siting process, creating opportunities for local learning. Opportunities may exist to remediate contamination and improve soil quality and quantity at borehole drilling locations. Opportunities may exist to improve access to and interpretation of sites of geological interest local to the borehole drilling locations.
Initial construction and underground based investigation	Effects during construction and underground based investigation could include: • Removal of soil and near-surface rock within the GDF surface site footprint • Disturbance/remobilisation of relict contamination (more likely on brownfield rather than greenfield sites) • Standard construction risks such as contamination from spillage of fuels, oils Estimates suggest that the volume of rock excavated for the GDF will be greatest from higher strength rock and least from evaporite rock. Although the physical arrangement of the underground	-	**Mitigation** Avoid sites with existing contamination or, if such a site is selected, advance remediation of the site to remove contamination. Such remediation could provide a positive benefit to a local community. Careful planning of the works and application of an environmental management plan to prevent contamination, spills. Any soils stripped from site to be handled and stored as per construction phase, and in accordance with a management plan. All soils stripped from site to be re-used in landscaping or otherwise beneficially/ sustainably re-used within two years.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	facilities is unknown in advance of detailed site-specific geological investigations, the size of the underground footprint of a lower strength sedimentary rock site is likely to vary substantially between host rock types. Illustrative figures calculated in 2015 based on the 2013 Inventory for Disposal suggest underground footprints in the region of: • About 7.6 km^2 for higher strength rock • About 15.3 km^2 for lower strength sedimentary rock • About 10.3 km^2 for evaporite rock In principle, excavations into the host rocks could affect the physical or chemical stability or the background level of seismicity of the surrounding geology. However, significant negative effects are not anticipated as a stable geological environment is essential for the GDF and the developer will need to demonstrate to safety and environmental regulators the long term safety of the facility.		**Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation **Enhancement** Knowledge of the geology and ground conditions will continue to improve through the construction phase, creating opportunities for local learning. Opportunities may exist to remediate contamination and improve soil quality and quantity during construction. Opportunities may exist to improve access to and interpretation of sites of geological interest local to the GDF or elsewhere.
Ongoing construction and operation	Underground excavation of vaults/tunnels would continue throughout this phase. If surface operational activities extend outside of the site area there may be additional effects on soil reserves and sites of geological value. Standard risks on any site operating large plant would apply, including potential contamination from spills of fuels, oils.	-	Continue construction phase measures, where appropriate.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Closure	Potential negative effects, for example moving of stored soil, could be sufficiently mitigated by implementing best practice guidance on soil handling and storage. Note that soils originally stripped from the site may not be suitable for restoration after many decades of storage; imported soil will be required. Risk of negative effect at source site. Risk of introduction of chemically/structurally inappropriate soils or soils containing ecologically inappropriate seeds. No significant effects on sites of recognised importance for their geological value (for example SSSI or RIGS) anticipated, as no further surface disturbance or development would take place unless activities extend outside of the development footprint.	-	**Mitigation** Careful preparation of site for reinstatement. Careful selection of soils for reinstatement of site – source of soils/soil type to be appropriate to the local geology and ecological context and from the nearest available location while avoiding negative effects at the source site. Soils to be restored onto a stable but permeable substrate, on appropriate gradients, with appropriate aftercare regime in place. **Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation. **Enhancement** Opportunities to be sought for beneficial/ sustainable re-use of any rock remaining in surface mounds – either incorporate into site restoration or find beneficial use elsewhere. Opportunities may exist to remediate contamination and improve soil quality and quantity during closure Opportunities may exist to improve access to and interpretation of sites of geological interest during closure

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

B4.1 Future baseline conditions

Potential future baseline conditions relevant to geology and soils are described in Appendix A for this theme. These potential future conditions are too complex/uncertain to allow an assessment to be made at this stage.

B5 The water environment

Note: The assessment set out in the table below represents the effects of development of the GDF on the objective in the absence of mitigation. However, it is assumed that any GDF is designed in accordance with 'best available techniques' (BAT), the requirements of the 'Groundwater Daughter Directive' and other regulatory requirements to protect the environment (and in particular the water environment), as without this it could not obtain an Environmental Permit or begin operation.

This means that, as a matter of course:

- The GDF will incorporate facilities to treat its own foul water, water drained from the surface site and water pumped from underground before discharge;
- That there would be facilities to attenuate any surface water run-off, preventing any increase in flood risk
- That drilling, mining and underground construction techniques and materials would be designed to prevent the release of contaminants into the groundwater
- That refuelling areas would be bunded and sealed to prevent release of hydrocarbons or other chemicals into the environment

All of the above are assumed as part of the basic GDF design, rather than as mitigation measures, and are therefore taken into account in the assessment. The result is to eliminate a number of potential effects on the water environment that would otherwise be hypothetically possible but would not occur in any development carried out responsibly and in accordance with regulatory requirements.

Table B5 The water environment

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Maintain and enhance water quality, minimise abstraction to conserve resources at sustainable levels. Minimise the risk of flooding.		
Siting process	Water will be required throughout the borehole drilling programme for: • Construction use, for example dust control, drilling fluid and cooling equipment • Drinking water, sanitary facilities	-	**Mitigation** Locate potential drilling sites/ compounds/access roads to avoid/minimise negative effects on the water environment. Ensure watercourse crossing numbers are

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	• Laboratory use Water will probably be brought to borehole sites by tanker. Effects of borehole construction and operation on water regime: • Potential for spillage and generates new discharge affecting the water quality or rate of flows of receiving waters • Could release contaminants to groundwater sources (for example spills of fuels, silty water) potentially affecting water quality if discharged untreated • Drilling pads, support infrastructure and access roads may increase flood risk by increasing impermeable surface areas, restricting flow at new culverts In consequence, all borehole construction sites would incorporate facilities for capture, storage and treatment of water before discharge, flood alleviation measures where required in line with the results of flood risk assessment and preventive measures to avoid releases of any contaminant to the ground or groundwater. Temporary flood control measures would be required at drill sites. Compounds/laydown areas and access roads to include appropriate design of watercourse crossings.		minimised and flood and pollution control measures incorporated where crossings are required. Identify/minimise potential abstraction needs and sources and consult early with regulatory authorities particularly with regard to resource scarcity and low flow watercourses. Design surface drainage for all relevant surface works incorporating sustainable drainage (SuDS) where possible, with attenuation to greenfield rates of run-off and no increase in run-off volumes where possible. Incorporate protection/ treatment of run-off to avoid siltation of watercourses where necessary. Establish appropriate pollution control measures in line with an environmental management plan. Drilling specification, inc. casings and fluid, designed to prevent entry of fluid to groundwater and incorporate regular monitoring. Ensure water discharge storage capacity available on site. Implement water re-use and efficiency measures to limit demand. Decommission boreholes in line with best practice guidelines and environmental management plan. **Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
			Enhancement Opportunities may exist at borehole drilling locations to enhance water quality and/or reduce the risk of flooding. Knowledge of the groundwater at each borehole drilling location will improve through the results of the siting process, creating opportunities for learning.
Initial construction and underground based investigation	Potential water requirements include: • Construction activities for example cement/grout mixing, cleaning machinery, dust control, pressure testing • Drinking water and canteen use, as well as toilet and washing facilities, and laundering protective clothing Drinking water supplies are expected to be obtained from an existing local utility water supply network, although in some circumstances it may be necessary to carry out upgrade works to enable this. Potential effects of construction use on water regime: • Reduce water availability or affect environmental flow targets • Removal of potentially significant quantities of groundwater (dewatering) could be required temporarily during the construction of the shafts and drift through near surface geological	-	**Mitigation** Environmental management plan(s) and Flood Risk Assessment. Construction site and permanent drainage to incorporate SuDS, with surface storage and attenuation to greenfield rates with no increase in run-off volume where possible. Establish pollution control measures. Grouting and lining of tunnel/ shafts to minimise water ingress. Plan works to minimise duration of dewatering requirements. Establish any treatment facilities early. Stockpile management procedures used to prevent risk of leachate, siltation especially lower strength sedimentary rock. Store any excavated evaporite rock under cover or export from site. Design development – once specific geological conditions are known, consider appropriateness

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	deposits • Such dewatering could affect surface water bodies through reduction in the water table, and through discharge of water with a high sediment load • Could increase flood risk by altering surface drainage patterns particularly through introduction of hardstanding areas and site clearance and levelling The effects of storing excavated rock in surface mounds could vary by type: • All rock types – siltation of water courses as a result of rainfall run-off • Lower strength sedimentary rock – contamination of surface watercourses (for example if the rock type contains enough sulphide for acid generating reactions on exposure to air and water) • Evaporite rock – halite is highly soluble in fresh water and therefore could contaminate surface water courses with salts • There would be less risk with the evaporite rock anhydrite Design measures in accordance with Flood Risk assessment to ensure the impact on areas of existing flood vulnerability (for example floodplains, coastal		of rock type for use in mounds and/or specific design requirements for mounds. **Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation. **Enhancement** Opportunities may exist to enhance water quality and/or reduce the risk of flooding. Opportunities may exist to provide enhancements to the water environment for example improvements to watercourses or creation of new features. Knowledge of the groundwater will continue to improve through this phase.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	zones or groundwater emergence zones) are considered in addition to ensuring the flood risk was not increased off site due to reducing permeability (stockpile areas) or increased hardstanding /built areas). SuDS design may contribute to the biodiversity objectives.		
Ongoing construction and operation	Underground excavation of vaults/tunnels would continue throughout this phase. Water requirements include: • Disposal tunnel construction (for example cement/grout mixing, cleaning machinery, dust control, pressure testing) • Routine processes such as wash-down and decontamination • Fire-fighting system • Drinking water and canteen use, toilet and washing facilities and laundering protective clothing Potential effects of ongoing excavation works on water regime: • Reduce water availability, or affect environmental flow targets • Affect water quality and/or flows of receiving waters through changed flow/volume and sediment load	-	In addition to the continuation of the above, where appropriate: • Continuous management/ maintenance of water environment mitigation and water management features on site.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	• Obstruct groundwater flows in aquifers on a localised scale, for example grouting/lining in the drift, shafts and tunnels acting as a barrier to normal flow patterns, or groundwater monitoring and control modifying flow patterns		
Closure	Water requirements include: • Activities associated with backfilling, for example cement/grout mixing, cleaning machinery, dust control, pressure testing • Routine processes (for example wash-down and cleaning machinery, and for domestic purposes such as toilet and washing facilities) • Effects on the water regime would initially be of a similar, or lesser, scale and nature to those described for the operational phase • Water use would reduce as closure progressed • Risk of contamination from accidental spillage would be reduced as the level of activity on site would be less For higher strength rock and lower strength sedimentary rock, large volumes of NRVB would be required for the backfill. For evaporite rock, backfill would be crushed rock salt, which would be the same as the host rock.	N	**Mitigation** All boreholes no longer required for ongoing monitoring to be decommissioned in accordance with best practice guidance current at the time Site restoration should ensure a similar surface run-off regime to that originally present, allowing for any other changes in the surrounding environment in the intervening decades (unless an alternative end state is agreed with the local community). **Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation **Enhancement** Opportunities may exist to enhance water quality and/or reduce the risk of flooding during closure

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

B5.1 Future baseline conditions

Potential future baseline conditions relevant to geology and soils are described in Appendix A for this theme. These potential future conditions may detract from the achievement of the environmental objective.

B6 Biodiversity, flora and fauna

Note: this topic is too dependent on site-specific information to allow an informed assessment to take place in line with the scoring system at this generic stage. The scores throughout this table are therefore given as 'not scored'.

Table B6 Biodiversity, flora and fauna

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Protect, enhance and promote natural biodiversity and habitats and seek to avoid their fragmentation.		
Siting process	Potential very short-term minor disturbance to wildlife during aerial and geophysical surveys would not cause any long-term or significant negative effect. Drilling campaign activities could result in the following negative effects: • Effects on designated/protected sites • Direct or indirect loss or fragmentation of habitat • Disturbance/displacement of wildlife as a result of noise, human presence and light pollution, potentially affecting breeding success and survival • Effects on biodiversity from accidental pollution incidents, contaminated drainage run-off or transport-related pollution Lack of site-specific information means the effects are unknown, as they are highly dependent on the actual habitats and species present in the vicinity of any actual works. However, advance desk-based studies and	X	**Mitigation** Full consideration of effects on biodiversity, flora and fauna and ecosystem services in the GDF siting process, in line with EIA. Design/implement all geophysical and borehole surveys with the advice of qualified and experienced ecologists and an environmental management plan. Identify any designated sites, sensitive habitats and records of protected species ahead of any surveys and avoid sensitive locations as far as possible. Consider seasonal sensitivities in planning the timing of all survey programmes so as to avoid/minimise disturbance at the most sensitive times of year, such as relevant breeding seasons in given habitats or for particular species groups. Reinstate working sites to ensure that habitats are returned to their previous condition or better, with appropriate aftercare.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	surveys should enable the avoidance of effects on the most sensitive locations for both the site and associated transport links. The temporary nature of the investigation works means that there is significant potential for mitigation and for site restoration once the works are complete. In consequence, it is likely that in the medium to long term all effects will be no worse than neutral.		If reinstatement cannot be achieved, provide compensatory habitat creation measures. **Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation. **Enhancement** Opportunities may exist to enhance natural biodiversity and habitats and create or improve linkages (corridors) local to the borehole drilling locations. Knowledge of the natural biodiversity and habitats at each borehole drilling location will improve through the results of the siting process, creating opportunities to promote these features.
Initial construction and underground based investigation	Construction activities could result in: • Effects on designated/protected sites • Direct or indirect loss or fragmentation of habitat as a result of presence of facility, including security fencing • Disturbance/displacement of wildlife as a result of noise, human presence and light pollution, potentially affecting breeding success and survival • Effects on biodiversity through accidental pollution incidents, contaminated run-off from surface drainage; or transport-related pollution	X	**Mitigation** Environmental management plan(s) will be required. Detailed design and layout of the GDF to seek to retain or minimise loss of any valuable biodiversity habitats and species and retain any linkages (corridors) between areas that could become isolated. If European designated sites may be affected, consideration must be given to the need for Habitats Regulations Assessment. If retention or other adequate mitigation cannot be achieved, then compensatory replacement habitat may be required off-site, potentially in

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	• Effects on aquatic habitats from discharges of drainage of underground workings (changes in the volume and rate of flow and in water chemistry) • Effects on aquatic habitats and aquatic wildlife species if dewatering of underground excavations affects water levels in surface water bodies and wetlands Effects could be direct (for example loss to hard engineering or access roads) or indirect (for example changes in character due to alterations in drainage patterns and deposition of pollutants). Surface disturbance could be less for evaporite rock, due to the smaller stored volume of excavated rock. The scale of construction is much greater than the scale of operations during the siting process. There is therefore the potential for effects on a larger scale, although limited to just one site. However, as with effects during the siting process, the actual effect is unknown, due to the lack of site-specific information about the species and habitats present. The longer term nature of the occupation of the site means that mitigation work would focus on habitat replacement or enhancement on land surrounding the GDF rather than habitat restoration in its original location.		tandem with landscape measures. **Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation. **Enhancement** Dependent on the site selected there may be potential to provide significant net biodiversity gains. Opportunities may exist to enhance natural biodiversity and habitats and create or improve linkages (corridors). Knowledge of the natural biodiversity and habitats will improve through this phase, creating opportunities to promote these features and for the local population to learn about them.
Ongoing construction	Underground excavation of vaults/tunnels would continue throughout this phase.	X	**Mitigation** Environmental management plan is required.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
and operation	There would be no new land take, and consequently no new loss of habitat or similar effects on biodiversity, assuming operational activities are within the surface site area. However, continued effects on biodiversity could result from operational activities: • Disturbance/displacement of wildlife due to noise, human presence, light pollution, road/rail kill potentially affecting breeding success and survival • Effects from accidental pollution incidents, contaminated run-off from surface drainage, or transport-related pollution • Effects on aquatic habitats from discharges of drainage of underground workings (changes in the volume and rate of flow and in water chemistry) Potential effects would depend on the biodiversity of the site and its surroundings before construction. Mitigation works would have been constructed in the previous phase. The focus in this phase would be on continuing maintenance and monitoring.		Ongoing management and maintenance of any biodiversity mitigation features on site (for example any created habitat) and for the associated transport links throughout the lifetime of the GDF. Monitoring to determine the effectiveness of mitigation measures (commencing immediately after their establishment in the construction phase), with additional remedial measures if they are not achieving defined targets. If retention or other adequate mitigation cannot be achieved, then compensatory replacement habitat may be required off-site, potentially in tandem with landscape measures. **Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation **Enhancement** Dependent on the site selected there may have potential to provide significant net biodiversity gains. Opportunities may exist to enhance natural biodiversity and habitats and create or improve linkages (corridors). Knowledge of the natural biodiversity and habitats will improve through this phase, creating opportunities to promote these features and for the local population to learn about them.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Closure	The remaining underground roadways, facilities and access tunnels would be backfilled and sealed. As these activities would probably take place within the surface site area, no further direct habitat loss or habitat change would be anticipated. Surface activities in support of backfilling and accidental release of substances may cause indirect effects (for example disturbance/displacement of fauna from the site and environs). However, these activities would be similar or lesser in scale and nature to the proposed operational activities. The risk of occurrence is lower, and effects are likely to be less, as species in the site and the surrounds are likely to have become acclimatised to activities on and around the GDF. Following backfilling, sealing and closure, it is assumed the site would be restored to as near its preconstruction condition as practicable. Any planting undertaken as part of landscape and biodiversity mitigation would probably have become well established and may be of biodiversity value; it is assumed that any such planting would be left in place.	X	**Mitigation** Pre-closure ecological surveys. Engagement with local stakeholders re desirable outcomes for biodiversity from site restoration, in the context of prevailing environmental conditions. Restoration of the site to its pre-development condition so far as possible, or better, modified as appropriate in the light of the preceding point (unless an alternative end state has been agreed with the local community). Appropriate aftercare/ management arrangements to ensure the long-term success of the biodiversity mitigation and reinstatement works. If retention or other adequate mitigation cannot be achieved, then compensatory replacement habitat may be required off-site, potentially in tandem with landscape measures **Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation **Enhancement** Dependent on the site selected there may have potential to provide significant net biodiversity gains Opportunities may exist to enhance natural biodiversity and habitats and create or improve

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
			linkages (corridors) Knowledge of the natural biodiversity and habitats will improve through this phase, creating opportunities to promote these features and for the local population to learn about them

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

B6.1 Future baseline conditions

Potential future baseline conditions relevant to biodiversity are described in Appendix A for this theme. It is envisaged that there will be changes in biodiversity baseline conditions over the lifetime of the project therefore the nature of the likely effects on biodiversity may also change. The drivers for change are complex, and their effects, alone and in combination are uncertain. Whatever the detailed outcomes it is likely that in addition to sites designated for their international, national and local importance for nature conservation, there will be much emphasis on landscape scale conservation and the need to maintain links through the landscape to allow species to move in response to climate change and other factors. Thus elements of any proposals which would result in fragmentation of habitats or severance of such links would be seen as more detrimental than may currently be the case. The potential future conditions are too complex/uncertain to allow an assessment to be made at this stage. Operational phase baseline monitoring and improved forecasting of future conditions is expected to reduce uncertainty in this regard.

B7 Traffic and transport

Note: There are overlaps between the effects noted in this topic and some other themes, particularly air quality, noise, biodiversity and climate change. Information provided in the Transport Logistics Report (2015) regarding the number of transport movements expected, is used to inform this assessment.

Table B7 Traffic and transport

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Minimise the need to travel, particularly by car or lorry, and minimise the levels of road congestion, maintaining and improving, where appropriate, travel facilities and choices and minimising the environmental effects of traffic. Seek to encourage alternative modes of travel (other than by car/lorry)		
Siting process	At any given time it is expected that two drilling rigs would be operating simultaneously. This is likely to require: • In the region of 80 car journeys and four buses per day for staff and visitor transport • In the region of 20 HGV trips per week, split between inbound and outbound movements • Following the completion of drilling operations, occasional return visits will be required to some of the borehole locations for testing purposes • This level of additional traffic is considered negligible and is not expected to have any measurable effect on the environment However, there is a small risk of nuisance due to: • Dust caused by vehicles travelling on	N	**Mitigation** Full consideration of the potential environmental effects of transport in the GDF siting process. Cover transportation effects in the environmental management plan for the drilling surveys. Seek opportunities to use more sustainable transport methods during the drilling surveys and to minimise reliance on private cars. Use locally sourced construction materials where possible. Access/transport routes to be designed to minimise effects of transport on sensitive receptors. Dust and mud suppression through use of wheel washing facilities and spraying water during dry and windy weather. Regular sweeping/cleaning of access points to the

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation		Potential mitigation measures, monitoring principles and opportunities for enhancement
	unsurfaced site access tracks • Mud carried by vehicle wheels from site access tracks onto the public highway			public road network. **Monitoring** Liaise with appropriate authorities regarding compliance with agreed mitigation **Enhancement** Opportunities may exist to address existing problems local to the borehole drilling locations such as improved safety measures, better junction layouts and improve access for local landowners
Initial construction and underground based investigation	Increase in traffic movements on the local road network surrounding the GDF site, associated with construction staff, HGVs, heavy plant, concrete tankers and deliveries, over a 15-year period. This may also require road widening. The Transport Logistics Report (2016) provides the following information on transport numbers during construction: • Car trips for staff and visitors would peak at approximately 600 per day, depending on: o Availability of shuttle buses o Availability of park-and-ride o Car occupancy rate • For freight transport, it is expected that rail transport will be available for construction of the underground facilities, but may not be available	-	- -	**Mitigation** Construction-phase environmental management plan to cover transport issues. Provision of a purpose built park-and-ride facility on a main highway Where practicable, provision for transport of equipment, materials and waste by rail or sea. Consider other alternatives to road transport (for example conveyors) if practicable. Consider potential longer-term/wider use of any new transport infrastructure. **Monitoring** Undertake monitoring in respect of Goods Vehicle Routing Agreement. **Enhancement** Opportunities exist to address existing transport problems for example improvements to existing

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation		Potential mitigation measures, monitoring principles and opportunities for enhancement
	for construction of the surface facilities. • If rail is the principal means of transport for materials, which is expected, there could be one train per day for spoil movements and the number of trains per day for construction materials would be one per day (as a worst case assumption: one train per day for each construction material). If road transport was the main transport method, which is not expected, then there could be: • A peak number of truck movements associated with excavated spoil of approximately 123 per day in higher strength rock, 77 per day in lower strength sedimentary rock and 88 per day in evaporate. • A peak number of up to ten trucks per day (up to 20 movements) for surface construction materials depending on rock type. • A peak number of 5 trucks per day in higher strength rock, 20 per day in lower strength sedimentary rock and 16 for evaporite for underground construction materials. In practice, even where rail facilities are available, it is likely that a mixture of rail and HGV transport will be used. This information suggests that the peak period of			roads (better junction layout, improved safety measures, improved access for local landowners) or provision of new transport infrastructure to alleviate existing traffic-related problems. Provision of a connection or better signage to existing cycle and pedestrian routes to encourage greater use of both specific routes and the wider public rights of way network. Provision of good access to the GDF by public transport, pedestrian and cycle links to reduce the need to travel by car. Provision of on-site facilities such as shops, banks and cafes at the GDF to reduce overall need to travel.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation		Potential mitigation measures, monitoring principles and opportunities for enhancement
	transport movements coincides with the peak period of construction of the surface facilities, prior to availability of a rail link. In principle, there is the potential for the following effects: • Severance to pedestrians/cyclists and loss of pedestrian/cyclist amenity • Community severance in local settlements • Driver delay and safety implications • Creation of nuisance dust • Transportation of mud and pollutants off site on vehicle wheels • Increase in greenhouse gas emissions However, the likelihood of occurrence and potential severity of many of these effects is extremely dependent on local conditions.			
Ongoing construction and operation	The greatest volume of construction-generated traffic would occur during the initial construction phase (see above). Thereafter (during the ongoing construction and operation phase), the volume of HGV movements associated with the excavated spoil, surface construction materials and underground construction materials would be expected to be lower. Based on transporting all LHGW radioactive waste packages by road during operation, the traffic numbers could be a peak of 2,600 trucks per year (7 per day) for the disposal of LHGW.	-	- -	**Mitigation** Periodic review and update of transportation related coverage in the environmental management plan(s). **Monitoring** Undertake monitoring in respect of Goods Vehicle Routing Agreement. Periodic review and update of transportation related coverage in the environmental management plan(s).

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation		Potential mitigation measures, monitoring principles and opportunities for enhancement
	If rail were used, this would equate to a peak of 217 trains per year, or less than one per day. An assumption of 80:20 ratio of rail to road transport would generate an average of just over 1 truck per day and less than one train per day. The Transport Logistics Report assumes all HHGW would be transported by rail. In principle, there is the potential for the following effects: • Severance to pedestrians/cyclists and loss of pedestrian/cyclist amenity • Community severance in local settlements • Driver delay and pedestrian delay together with associated safety implications • Creation of nuisance dust • Transportation of mud and pollutants off site on vehicle wheels • Increase in greenhouse gas emissions However, the likelihood of occurrence and the significance of many of these effects is extremely dependent on local conditions. Notwithstanding this, the local environment and sensitivity of local receptors will need to be considered together with the magnitude of the change of flow to determine the significance of effects.			**Enhancement** Opportunities exist to address existing transport problems for example improvements to existing roads (better junction layout, improved safety measures, improved access for local landowners) or provision of new transport infrastructure to alleviate existing traffic-related problems. Provision of a connection or better signage to existing cycle and pedestrian routes to encourage greater use of both specific routes and the wider public rights of way network. Provision of good access to the GDF by public transport, pedestrian and cycle links to reduce the need to travel by car. Provision of on-site facilities such as shops, banks and cafes at the GDF to reduce overall need to travel.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Closure	In HSR bentonite would be imported to the site for the progressive backfilling of disposal areas. Nirex Reference Vault Backfill (NRVB), would be imported during facility closure for backfilling vaults in higher strength rock and lower strength sedimentary rock. Also during facility closure, part of the mounds would be used as mass backfill (for some rock types). In evaporite rock types crushed evaporite would be imported to the site for the progressive backfilling of HHGW disposal tunnels. Magnesium oxide (MgO), would be imported to the site for chemical conditioning of the LHGW waste packages – with bags of MgO being placed on top of each stack of packages. The Transport Logistics Report (2016) states that at the end of the life of the GDF there will be a number of transport movements relating to the closure and restoration of the site. The average number of staff journeys by car during closure would be between approximately 10 and 50 per day, again depending on factors such as the availability of shuttle buses and park-and-ride facilities, and the car occupancy rate. The number of bus journeys (direct, shuttle and park-and-ride) could be approximately 1-5 per day; whilst approximately 5 people could be expected to walk or cycle to the site per day. Coming at the end of many decades of much higher traffic, this large reduction in the level of car traffic around the GDF for the 10-year closure phase would be seen as an improvement.	-	**Mitigation** Periodic review and update of transportation related coverage in the environmental management plan(s). **Monitoring** Undertake monitoring in respect of Goods Vehicle Routing Agreement. Periodic review and update of transportation related coverage in the environmental management plan(s). **Enhancement** Opportunities may exist to make further improvements to roads through closure (better junction layout, improved safety measures, improved access for local landowners) or provision of new transport infrastructure to alleviate existing traffic-related problems. Provision of a connection or better signage to existing cycle and pedestrian routes to encourage greater use of both specific routes and the wider public rights of way network. Provision of good access to the GDF by public transport, pedestrian and cycle links to reduce the need to travel by car during closure. Provision of on-site facilities such as shops, banks and cafes at the GDF to reduce overall need to travel would continue through closure and be the last facilities to be closed, should this be the

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
			decision taken.

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

Note that where more than one score is provided, this represents a range of scores (for example, minor to major negative). This approach has been utilised where adverse effects are likely (before mitigation) but the significance of effect would depend on site-specific factors.

B7.1 Future baseline conditions

Potential future baseline conditions relevant to traffic and transport are described in Appendix A for this theme. These potential future conditions are too complex/uncertain to allow an assessment to be made at this stage.

For longer timescales, existing forecast models become less reliable and it is appropriate to consider changes that are consistent with policy directions that reflect the key factors that are currently driving transport policy; climate change and the prospect of diminishing fossil fuel reserves. Committed development traffic is conventionally associated with developments that are known to be coming forward as part of the planning process. Since the timescales involved with the GDF go well beyond the horizon over which the planning system identifies new development, it is impossible to make allowance for specific committed development.

B8 Air quality

Table B8 Air quality

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Minimise the emission of pollutants and air quality impacts relative to statutory levels, where possible. Seek to enhance air quality through opportunities locally to help achieve the objectives in the EU Directive 'on ambient air quality and cleaner air for Europe'.		
Siting process	Effects of surface-based site investigations: • The car journeys per day generated by the siting process are not expected to exceed the indicative EPUK/IAQM criteria[6] for determining when an assessment is required of 100 LDVs within an AQMA and 500 elsewhere, and the impacts are not likely to be significant • Experience suggests that exhaust emissions from on-site construction plant are not likely to be significant • It should be possible to reduce the risk of dust impacts during construction of drilling pads, compounds, access routes with the implementation appropriate and well-established management methods	N	**Mitigation** Effective measures within environmental management plan, designed to achieve: • Minimisation of emissions from on-site plant • Minimisation of emissions from vehicles • Minimisation of generation of dust • Suppression of dust during dry weather **Monitoring** Monitoring in relation to air quality and dust will be a continuous ongoing activity. Liaise with appropriate authorities regarding compliance with agreed mitigation. **Enhancement** Opportunities to improve the existing air quality

[6] The EPUK/IAQM indicative criteria are provided in terms of the number of Light Duty Vehicles (LDVs) and Heavy Duty Vehicles (HDVs). HDV is the total number of HGVs and buses. The term 'trucks' used in the Transport Logistics Report is taken to mean HGV and has been used interchangeably with HDV.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation		Potential mitigation measures, monitoring principles and opportunities for enhancement
	• The thermal input of the back-up and emergency generators is not provided in the GDF Designs report so it is not possible to determine whether the indicative EPUK/IAQM criteria will be exceeded. Based on paragraph 10.4 of the GDF Designs report, which states that the *'total power demand for the GDF is 20 MVA at full operational load. The essential load, as supported by the dedicated diesel generators, is estimated to be in the region of 5.5MVA'* there is the potential for local air quality impacts from back-up and emergency generators with a thermal input of more than 300 kW; however, with an appropriate stack height these impacts are unlikely to be significant.			situation may be explored and these may be similar to those set out for traffic and transport for example improvements to existing roads or provision of new transport infrastructure to alleviate existing traffic-related problems. Opportunities may exist to address existing problems associated with dust local to the borehole drilling locations.
Initial construction and underground based investigation	Construction activities are expected to generate between 10 and 20 HGV movements (see Transport Logistics Report, page 29, footnote to Tables 5, 6 and 7). This is below the indicative EPUK/IAQM criteria for determining when an air quality assessment is required of 25 HDVs within an AQMA and 100 HDVs elsewhere. On that basis, the impacts associated with the HGV movements are not likely to be significant. Nevertheless, around 600 car trips per day are expected to be generated during construction (see Transport Logistics Report, page 33, Table 11). This would exceed the indicative EPUK/IAQM criteria for	-	- -	**Mitigation** Appropriately designed ventilation systems, in accordance with best practice, to minimise emissions of pollutants. **Monitoring** Monitoring in relation to air quality and dust will be a continuous ongoing activity. Liaise with appropriate authorities regarding compliance with agreed mitigation. **Enhancement** Opportunities to improve the existing air quality

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation		Potential mitigation measures, monitoring principles and opportunities for enhancement
	determining when an assessment is required of 100 LDVs within an AQMA and 500 elsewhere and an assessment would be required to determine whether the air quality impacts are likely to be significant. Dust generated during construction activities, particularly earthworks, soil stripping, storage and use of materials on site and excavations could have an impact on local air quality if unmanaged, particularly through the generation of dust.			situation may be explored and these may be similar to those set out for traffic and transport for example improvements to existing roads or provision of new transport infrastructure to alleviate existing traffic-related problems.
Ongoing construction and operation	Around 300 car trips per day are expected to be generated during the operational phase (see Transport Logistics Report, page 33, Table 12) and the indicative EPUK/IAQM criteria for determining when an air quality assessment is required of 100 LDVs within an AQMA would be exceeded. An assessment would be required to determine whether the impacts are likely to be significant. Outside an AQMA, the indicative criteria of 500 LDVs would not be exceeded and an assessment would not be required and the impacts are unlikely to be significant. Other effects of operation include: • Dust generated from surface handling of excavated rock and other materials associated with vault and disposal tunnel construction and backfill activities, could have an impact on local air quality/nuisance if unmanaged. However, particularly on an established operation at a fixed site, this can normally be prevented through established control methods	-	- -	**Mitigation** In addition to the continuation of the above, where appropriate: Environmental management and monitoring in relation to air quality and dust will be a continuous ongoing activity requiring resources. **Monitoring** Monitoring in relation to air quality and dust will be a continuous ongoing activity Periodic review and updating of the environmental management plan Liaise with appropriate authorities regarding compliance with agreed mitigation **Enhancement** Opportunities may exist to address existing air quality problems for example improvements to existing roads (better junction layout) or provision of a bypass as an enabler of the GDF and/or delivered as part of the community investment

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation		Potential mitigation measures, monitoring principles and opportunities for enhancement
	and these are assumed to be in place. • The thermal input of the back-up and emergency generators is not provided in the GDF Designs report so it is not possible to determine whether the indicative EPUK/IAQM criteria will be exceeded. Based on paragraph 10.4 of the GDF Designs report, which states that the *'total power demand for the GDF is 20 MVA at full operational load. The essential load, as supported by the dedicated diesel generators, is estimated to be in the region of 5.5MVA'* there is the potential for local air quality impacts from back-up and emergency generators with a thermal input of more than 300 kW; however, with an appropriate stack height these impacts are unlikely to be significant. • On-site emissions of dust and fumes/gases from the ventilation systems would be discharged through a stack and could negatively affect local air quality. However, such emissions would be subject to testing against regulatory limits to comply with the site's environmental permit. All discharges from the ventilation system would be emitted though a stack located at the side of ventilation			

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	fan house. With appropriate stack heights, it is normally possible to ensure that impacts are not significant.		
Closure	The 10 – 50 daily car trips generated during closure (see Transport Logistics Report, page 34, Section 9.4) is below the EPUK/IAQM indicative criteria for determining when an air quality assessment is required of 100 LDVs within an AQMA and 500 elsewhere, therefore the impacts are not likely to be significant. Demolition and clearance activities on site could give rise to emissions of dust impacts. However, it should be possible to reduce the risk through the implementation of appropriate and well-established management methods	N	**Mitigation** Dust suppression measures may be particularly required during demolition/ clearance of the surface facilities Environmental management and monitoring in relation to air quality and dust will be a continuous ongoing activity requiring resources. **Monitoring** Monitoring in relation to air quality and dust will be a continuous ongoing activity Periodic review and updating of the environmental management plan Liaise with appropriate authorities regarding compliance with agreed mitigation **Enhancement** Opportunities may exist to address existing air quality problems for example improvements to existing roads (better junction layout) or provision of a bypass

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

Note that where more than one score is provided, this represents a range of scores (for example, minor to major negative). This approach has been utilised where adverse effects are likely (before mitigation) but the significance of effect would depend on site-specific factors.

B8.1 Future baseline conditions

Potential future baseline conditions relevant to air quality are described in Appendix A for this theme. These potential future conditions are too complex/uncertain to allow an assessment to be made at this stage.

B9 Climate change

A study was carried out in 2009-10 [2] to analyse the potential carbon footprint of developing the GDF, covering the surface investigations and the construction, operation and closure periods. This study has been updated in 2015-16, taking into account the revised inventory for disposal figures, the revised illustrative designs for the disposal facility and associated transport system, the revised construction and operational phase programmes, the revised assumptions regarding mode of travel for staff to and from site and additional and more detailed analysis of embodied material impacts. This section is therefore based on the updated report [23].

Table B9 Climate change

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Minimise greenhouse gas emissions, encourage adaptability to climate change and encourage the use of low carbon technology. Promote energy generation from renewable sources.		
Siting process	A broad range of activities and the use of materials with embedded energy are likely to give rise to carbon emissions during the borehole drilling programme. The construction and operation of the deep boreholes is estimated to generate in the region of 5,800 tonnes of carbon dioxide in total (irrespective of rock type). The major contributions to the footprint are the creation of access roads to the borehole drilling pads; operation of static and mobile rigs/forklift trucks; and operation of offices and other facilities. The siting process is relatively unique to the development of the GDF, and therefore it is not feasible to compare the estimated tonnes with other infrastructure projects, as has been done in the benchmarking exercise within the carbon report for the construction and operation stages. To add some context to the estimated tonnes of carbon dioxide,	N	**Mitigation** Full consideration of climate change issues in the siting process. Seek to minimise embodied energy/carbon in construction materials. Design and locate site offices to maximise energy efficiency. Incorporate energy efficiency/ emission reduction measures in environmental management plan. Maximise use of renewable energy sources, including alternative fuel sources for site based equipment. Consider opportunities to minimise carbon dioxide emissions associated with staff travel, including provision of alternative modes of transport. **Monitoring**

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation		Potential mitigation measures, monitoring principles and opportunities for enhancement
	World Bank figures indicate per-capita carbon dioxide emissions in the UK in 2011 were around 7.1 tonnes per person, so the emissions from the borehole surveys over a 10-year period are equivalent to those from about 80 typical individual people over the same period. This effect is considered negligible.			Monitoring in relation to greenhouse gas emissions will be a continuous ongoing activity. Set targets for use of renewable energy during construction. **Enhancement** Opportunities may exist to increase the proportion of energy generated from renewable sources for operations associated with the siting process. Opportunities may exist to increase the proportion of energy generated from renewable sources locally through community investment.
Initial construction and underground based investigation	carbon dioxide emissions arising from direct or indirect combustion of fossil fuel (from construction traffic and plant, generators, embodied energy within construction materials used) and transport would contribute to climate change. The 2016 study quantified carbon emissions for all construction activities (including ongoing construction) at around 0.63 million tonnes for a higher strength rock site, around 1.4 million for the lower strength rock and around 0.48 million tonnes for the evaporate rock. The number of disposal vaults and tunnels proposed for each rock type, and the associated design differences, are the main factors influencing the difference in estimated carbon emissions. This includes estimated larger quantities of excavated rock spoil likely in the case of the lower strength sedimentary and evaporite rock types. In both the higher and lower strength sedimentary rock	-	- -	**Mitigation** Consider climate-change issues, including resilience to change, adaptability and climate-change effects, in the construction-phase environmental management plan. Use/specify materials with high recycled content and inherently low embodied carbon content, for example use of a percentage of pulverised fly ash or ground granulated blast-furnace slag for concrete/shotcrete, and recycled steelwork. Minimise distances for transporting construction materials to site, through specification of local sources where feasible. Minimise distance for offsite spoil disposal. Maximise use of renewable energy sources. Consider opportunities to minimise carbon dioxide emissions associated with staff travel, including

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation		Potential mitigation measures, monitoring principles and opportunities for enhancement
	environments, the amount of embodied carbon associated with construction, backfill and buffer materials is higher than that associated with an evaporite environment. During construction, this is due to the differences in volumes of concrete and shotcrete used. The carbon report compares the estimated carbon emissions with other large infrastructure projects. This concludes that the other projects generally have a lower proportion of embodied carbon than that estimated for the GDF. Otherwise, given the relative scale and nature of the projects they are broadly comparable. Adaptation to future climatic conditions, as a result of climate change, is addressed under other relevant topics, as part of the consideration of future baselines.			provision of alternative modes of transport (alternatives to car travel, such as provision of staff park and ride facility or measures to encourage cycling) and/or site based worker accommodation. **Monitoring** Monitoring in relation to greenhouse gas emissions will be a continuous ongoing activity. Set targets for use of renewable energy. **Enhancement** Opportunities may exist to increase the proportion of energy generated from renewable sources to power operations associated with initial construction and underground based investigations. Opportunities may exist to increase the proportion of energy generated from renewable sources locally through community investment.
Ongoing construction and operations	Surface construction would be limited during this phase but underground excavation/construction would continue throughout this phase and would continue to contribute to climate change. Overall, construction of the disposal vaults is by far the largest contributor of emissions over the whole lifetime of the GDF. This is quantified in the tonnage figures presented above, and not repeated here. The means by which radioactive waste is transported to the facility will be key to the operation related footprint, independent of rock type. The 2016 study	-	- -	**Mitigation** Environmental management regarding climate change adaptability and resilience throughout operational period. Appropriate response to change as observed. Periodic review and update of environmental management plan(s). Transport mode for radioactive waste and distance travelled to site. Use/specify materials with high recycled content

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	quantified carbon emissions in the operational phase for two different transport scenarios. This estimated around 1.5 million tonnes of carbon dioxide for all rock types, when transporting waste packages by road and rail, and around 1.4 million tonnes when transporting waste packages by sea, road and rail. Adaptation to future climatic conditions, as a result of climate change, is addressed under other relevant topics, as part of the consideration of future baselines.		and inherently low embedded carbon content, for example use of a percentage of pulverised fly ash or ground granulated blast-furnace slag for cement mixes (although would need review of safety function to ensure design integrity). Consider opportunities to minimise carbon dioxide emissions associated with staff travel. Maximise use of renewable energy sources. Consider opportunities to minimise carbon dioxide emissions associated with staff travel. **Monitoring** Monitoring in relation to greenhouse gas emissions will be a continuous ongoing activity. Set targets for use of renewable energy. **Enhancement** Opportunities may exist to increase the proportion of energy generated from renewable sources to power operations associated with ongoing construction and operation. Opportunities may exist to increase the proportion of energy generated from renewable sources locally through community investment.
Closure	Excavation of disposal vaults and emplacement of radioactive waste would cease; the principal activities would be backfilling the remaining underground facilities, including the access shafts and drift, decommissioning of the surface facilities and site restoration (depending on the end state agreed with	-	**Mitigation** Full consideration of climate change issues in the decision making process for the end state of the GDF site Use/specify materials with high recycled content and inherently low embedded carbon content for

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	the local community). The 2016 study quantified carbon dioxide emissions in this phase at around 5.2 million tonnes for higher strength rock, around 2.3 million for lower strength sedimentary rock and around 70,000 for evaporite rock. The carbon report compares the estimated carbon emissions with other large infrastructure projects. This concludes that the other projects generally have a lower proportion of embodied carbon that that estimated for the GDF. In both the higher and lower strength sedimentary rock environments, the amount of embodied carbon associated with construction, backfill and buffer materials is an order of magnitude higher than that associated with an evaporite environment. This is largely due to the need for backfill and buffer materials with high embodied energy coefficients, such as NRVB, cementitious grouts and bentonite. Otherwise, given the relative scale and nature of the projects they are broadly comparable. Following closure the potential climate change effects described above at the surface would no longer have any effect on the GDF. The safety case for the facility would however be expected to demonstrate that the facility would remain safe in light of the potential longer term climate trends such as sea level rise and glacial cycles.		backfill and buffer materials, where feasible. Minimise additional import of materials for buffer/backfill, and consider alternative modes of transport for imported materials required. Maximise use of renewable energy sources **Monitoring** Monitoring in relation to greenhouse gas emissions will be a continuous ongoing activity Set targets for use of renewable energy **Enhancement** Opportunities may exist to increase the proportion of energy generated from renewable sources to power operations associated with closure Opportunities may exist to increase the proportion of energy generated from renewable sources locally through community investment

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

Note that where more than one score is provided, this represents a range of scores (for example, minor to major negative). This approach has been utilised where adverse effects are likely (before mitigation) but the significance of effect would depend on site-specific factors.

B10 Noise and vibration

Note: this topic is too dependent on site-specific information to allow an informed assessment to take place in line with the scoring system at this generic stage. The scores throughout this table are therefore given as 'not scored'.

See Appendix B Table 6 for quantified figures on transport numbers, based on the Generic Transport Assessment (GTA).

Table B10 Noise and vibration

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Minimise noise and vibration effects as far as reasonably practicable. Seek to enhance existing conditions where possible.		
Siting process	Seismic and aerial surveys would generate noise and vibrations (for example explosives, aircraft and vibroseis trucks), but would likely be of low amplitude or short (transient) duration and therefore the effect would probably be negligible. Effects from site investigation (deep borehole survey) works include: • Perceptible increases in noise and vibration, particularly from drilling rigs (continuous and intermittent noise), diesel generators (if applicable) and works traffic (HGVs) • Seismic and aerial surveys would also generate noise and vibrations (for example explosives, aircraft and vibroseis trucks), but would likely be of low amplitude or short duration and therefore the effect would probably be negligible	x	**Mitigation** Full consideration of noise and vibration issues in the siting process Best practice measures to limit noise levels, expressed through an environmental management plan Noisiest activities to be limited to certain times of day and weekdays only, where possible. Assuming that noise sensitive receptors lie within 1 km or so of the borehole drilling locations, noise and, if necessary, vibration and air overpressure limits will be agreed with the consenting body **Monitoring** A monitoring strategy will be developed and agreed with the consenting body and then implemented as necessary. Monitoring in relation to noise and vibration will be a continuous ongoing activity

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	Generators and drilling activities associated with site investigation works are likely to generate some noise and, potentially, vibration. Road traffic levels are expected to be too low to contribute significantly to noise. If sensitive receptors (for example occupants of residential buildings, community and recreational facilities) are present in proximity to the works they may be affected, although noise effects are more likely than vibration effects. However, the number and sensitivity of receptors affected and the magnitude of effects cannot be quantified at this stage.		Liaise with appropriate authorities regarding compliance with agreed mitigation **Enhancement** Opportunities may exist (such as improved junction layouts set out in the traffic and transport theme above) to address existing noise and vibration problems local to the borehole drilling locations as an enabler of the siting process and/or delivered as part of the community investment.
Initial construction and underground based investigation	Perceptible increases in noise both continuous and intermittent from: • excavation and piling works • earth moving equipment, construction plant, diesel generators • construction vehicles (HGVs, concrete trucks, forklift trucks, delivery vehicles, vans and personnel vehicles) • freight trains, once the rail link is in operation • ventilation, power and access systems for the underground workings Calculated levels of road traffic (staff and HGV deliveries) are too low to contribute significantly to noise levels. Noise from construction would be greatest during	x	**Mitigation** In addition to the continuation of the above, where appropriate: Construction-period environmental management plan Detailed design of surface facilities to minimise noise of both construction and future operational activities through: • Choice of plant; • Layout and design of facilities • Enclosing noisy plant or activities • Incorporation of noise barriers/baffles at sources of noise If required, incorporate noise barriers (mounds or

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	surface construction and shallow excavations, reducing as the depth of excavation increases. Airborne vibration is unlikely to be an issue unless properties are located within 40 metres of the source (based on Highways Agency guidance), and most potential sources are unlikely to be within 40 of the site boundary. Similarly, ground-borne vibration is only likely to affect receptors in close proximity to the source, and most sources will be located well within the site. Depending on proximity to the site, noise associated with construction may have an effect on sensitive receptors (occupants of residential buildings, community and recreational facilities and noise sensitive businesses and enterprises). However, the need to adhere to the requirements of legislation should reduce this. The use of different construction techniques would probably not result in any significant differences in effects, as specified noise limits for the works would need to be adhered to. Due to lack of site-specific information, the potential for effects would depend on the proximity of the site and works to sensitive receptors, level and extent of noise and vibration generated and ground conditions. It should be noted that mounds formed of soils and other materials stripped from the surface site and of excavated rock from the underground workings would form a significant barrier to noise and would reduce negative effects on any nearby residential properties.		vertical barriers) into the detailed design of the site, potentially as part of landscape works. Assuming that noise sensitive receptors lie within 1 km or so of the GDF site, noise and, if necessary, vibration and air overpressure limits will be agreed with the consenting body **Monitoring** A monitoring strategy will be developed and agreed with the consenting body and then implemented as necessary. Noise monitoring at the site boundary and at nearby sensitive receptors Monitoring in relation to noise and vibration will be a continuous ongoing activity **Enhancement** Opportunities may exist (such as improved junction layouts set out in the traffic and transport theme above) to address existing noise and vibration problems local to the GDF as an enabler of initial construction and underground based investigation and/or delivered as part of the community investment.

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	Should potential noise effects be an issue at the GDF site, then design and placement of the mounds would be a significant means of reducing those effects.		
Ongoing construction and operation	Significant sources of noise during operation would include: • Delivery of radioactive waste for disposal in the GDF • Delivery of backfill material • Removal and surface handling of excavated rock spoil from ongoing underground excavations and management of surface mounds (on-site works, plus freight train deliveries and road traffic) • Ventilation, power and access systems for the underground workings Calculated levels of road traffic (staff and HGV deliveries) are too low to contribute significantly to noise levels. Depending on proximity, there is potential for negative effects on sensitive receptors (occupants of residential buildings, community and recreational facilities, noise sensitive businesses and enterprises and nature conservation areas). Noise levels are likely to be lower than during the construction phase. Note the comments about mounds made under the construction phase summary. At this stage no site has been selected and	x	**Mitigation** In addition to the continuation of the above, where appropriate: Any required screening should already be in place by the start of the operational period. Maintenance will be an ongoing activity. **Monitoring** In addition to the continuation of the above, where appropriate: Ongoing noise monitoring to ensure that defined targets are not exceeded; remedial measures if they are. Monitoring of other development proposals to comment on planning applications if they are sufficiently close that complaints about noise may arise. Assuming that noise sensitive receptors lie within 1 km or so of the GDF site, noise and, if necessary, vibration and air overpressure limits will be agreed with the consenting body and a monitoring strategy will be developed and agreed with the consenting body and then implemented as necessary. **Enhancement** Opportunities may exist (such as improved

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	subsequently the effect as assessed is uncertain. The potential for effects would depend on the proximity of the site and works to sensitive receptors, ground conditions and the level and extent of noise generated. Vibration is unlikely to be a significant issue during operation.		junction layouts set out in the traffic and transport theme above) to address existing noise and vibration problems local to the GDF as an enabler of this phase and/or delivered as part of the community investment.
Closure	Sources of noise during the closure phase would include: • Delivery of backfill material (by freight trains, HGVs or a combination of the two) • Decommissioning and demolition activities on the surface facilities Calculated levels of road traffic (staff and HGV deliveries) are too low to contribute significantly to noise levels. The effect on sensitive receptors is not likely to be significant and is likely to be less than that of the construction and operational phases. As no site-specific data is available 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.	x	As per operations phase, with adaptations as required.

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

B10.1 Future baseline conditions

Potential future baseline conditions relevant to noise and vibration are described in Appendix A for this theme. These potential future conditions are too site-specific, complex/uncertain to allow an assessment to be made at this stage.

B11 Land use and community

Table B11 Land use and community

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Minimise consumption of, and reduce damage to, undeveloped land and agricultural holdings through re-use of previously developed land and existing buildings where possible. Protect and enhance recreational resources, land and facilities valued by the local community.		
Siting process	It is assumed that the borehole drilling programme would involve temporary land take as follows: • Up to 20 deep boreholes within a target area of approximately 10 km^2 with the possibility of one or more deep boreholes outside the target area • Each deep borehole compound to be occupied for approximately six months • Temporary access tracks to the compounds (length unknown) • Further, shorter-term and smaller-scale land-take for shallow borehole surveys All of the above would be replicated for each potential site being investigated. For greenfield sites, negative effects of temporary land-take and temporary impacts on community resources could include: • Damage to agricultural soils and/or drainage or water supply system	-	**Mitigation** Full consideration of land-use effects in siting process. In detailed design of site-based investigations, seek to minimise number of sites required & extent of land required at each site. Locate drilling sites with reference to existing roads/tracks to minimise length of new temporary access tracks. Consult landowners and tenant farmers in selecting locations and access routes to minimise disruption. Seek to locate drilling sites, site offices on previously developed land where it is available in suitable locations. Seek to avoid existing community resources where possible, including public rights of way. Develop a site-specific soil handling strategy in liaison with appropriate stakeholders in accordance with the best practice guidance (DEFRA 2009 Guide for the Sustainable Use of

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	• Damage to the agricultural land quality according to the Ministry of Agriculture Fisheries and Food Agricultural Land Classification System (1988) • Temporary loss or severance of agricultural land, agricultural productivity, agricultural access and disruption of agricultural practices • Temporary loss or severance of community resources such as land use by the community, public rights of way or other recreational land or facilities The effects cannot be assessed in detail until the location of the affected land and community resources and the survey areas are known, and therefore the nature of the affected land and resources. However, on a generic basis, the temporary nature of the occupation and the high potential for site restoration and re-instatement of community resources means that the effects are unlikely to be significant in the long term.		Soils on Construction Sites and the MAFF Soil Handling Guide 2000) to effectively reinstate the disturbed areas to their former agricultural use. Consider balance between land-use and community effects and mitigation requirements of other topics which may require the use if additional land. **Monitoring** A strategy will be developed, agreed and implemented to monitor the performance of mitigation measures regarding recreational resources and land and facilities valued by the local community A soil handling strategy would be implemented including on site monitoring and the regular review of the strategy with appropriate stakeholders **Enhancement** Opportunities may exist to improve agricultural land quality and agricultural holdings through the reinstatement of borehole drilling locations Opportunities may exist to re-use and enhance previously developed land and existing buildings Opportunities may exist to enhance recreational resources and land and facilities valued by the local community through the reinstatement of borehole drilling locations or through community investment

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation		Potential mitigation measures, monitoring principles and opportunities for enhancement
Initial construction and underground based investigation	Assumed land take requirements for the GDF: • Surface facilities – around one square kilometre • Additional land for new/improved transport infrastructure – unknown It may also be necessary to take additional land for environmental mitigation measures. Unlike during the siting process, land-take effects in the construction phase would be long-term, generally lasting at least until the end of the closure phase. Negative effects could include: • Loss of agricultural land • Loss of community resources including land used by the community and recreational facilities • Loss of agricultural or other soils • Severance/disruption to agricultural drainagewater supply and access systems • Conflict with land-use related policy at national or local level (to be weighed against the strategic importance of the GDF in national policy terms) Negative effects on land use and community resources are likely but the significance will depend on land quality and the characteristics of the surrounding area and the nature and distribution of community	-	- -	**Mitigation** In addition to the continuation of the above, where appropriate: The extent of land take required should be refined as the design of the GDF develops to allow more accurate assessment of the likely land use and community effects at the siting stage. Ensure that any consideration of land-use and community effects includes for land required for off-site environmental mitigation measures and for any off-site transport infrastructure. Ensure that rights of access for maintenance are secured to any off-site mitigation features. Mitigation measures would be put in place to ensure that community effects are reduced as far as practicably possible, including the temporary diversion of public rights of way, where required, to maintain the connectivity of the network. These measures would be subject to consultation with the relevant stakeholders including local authorities and access groups Mitigation measures would be put into place to ensure that potential effects on soils and agricultural land quality are reduced as far as possible. **Monitoring** A soil handling strategy would be implemented including on site monitoring and the regular review of the strategy with appropriate

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	resources. The assessment cannot consider interactions with land-use and community policy before the site has been identified, and requires inclusion of local policy, likely to be covered at project EIA stage. Should new port infrastructure be required for the transport of radioactive waste by sea, the land use and community effect of this would need to be assessed separately. Community investment opportunities that would result from the construction of the GDF are set out in the 2014 White Paper 'Implementing Geological Disposal'. These relate, inter alia, to the generation of jobs, and improvements in infrastructure and community facilities. These aspects are covered in generic socio-economic assessment reports.		stakeholders A strategy will be developed, agreed and implemented to monitor the performance of mitigation measures regarding recreational resources and land and facilities valued by the local community Ongoing monitoring of enhancement provided through the community investment **Enhancement** Opportunities may exist to re-use and enhance previously developed land and existing buildings There may be opportunities to provide additional community facilities on site during operations (for example public open space). Opportunities may exist off site to enhance recreational resources and land and facilities valued by the local community through community investment Opportunities may exist to create new recreational resources and land and facilities to be valued by the local community through the community investment
Ongoing construction and operations	There would be no new land-take during the operational phase; however, all land-use effects initiated during the construction phase would continue during the operational phase. Impacts on communities and community resources during construction may or may not remain during the operational phase for example public rights of way	-	**Mitigation** In addition to the continuation of the above, where appropriate: Ongoing maintenance of the GDF estate, including any off-site environmental mitigation features (to be covered in the operational phase

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	diverted during the construction phase may be re-instated along their original alignment during operations or may remain along their diverted route.		environmental management plan). **Monitoring** Ongoing monitoring of enhancement provided through the community investment **Enhancement** There may be opportunities to provide additional community facilities (for example public open space) off site through community investment.
Closure	Any land use effects associated with the presence of the GDF will remain through the duration of the closure works (backfilling & sealing). Impacts on communities and community resources may or may not remain during this phase. Following closure, the land would be returned to as close to pre-construction condition as practicable (unless an alternative end state is agreed with the local community). Some or all surface mounds may remain in place, limiting the potential for restoration. So far as possible, community landscape and ecological mitigation works would remain in place. Once completed, the effect and significance would vary depending on site restoration and surrounding land uses. A positive effect would be seen where land could be re-used for either its previous purpose (or another as appropriate). The developer 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.	x	**Mitigation** In addition to the continuation of the above, where appropriate: The closure strategy is to remediate and landscape the surface environment to the end state agreed with the Government, regulators and the local community. Therefore, careful consideration should be given to the restoration strategy and potential after-uses of the land as the time of closure approaches, with input from local stakeholders. Careful consideration should also be given to any impacts on communities and community resources resulting from the closure of the site, in consultation with the relevant local authorities **Monitoring** Ongoing monitoring of enhancement provided through the community investment **Enhancement** There may be opportunities to provide additional

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	No assessment has been made due to uncertainty about the final end-use for the GDF site after closure.		community facilities on site during closure (for example public open space) or off site through community investment. These opportunities would be developed in consultation with stakeholders including local authorities, community groups and other relevant interest groups and implementation would be monitored during the operational phase. Opportunities may exist to improve agricultural land quality and create new agricultural holdings

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

Note that where more than one score is provided, this represents a range of scores (for example, minor to major negative). This approach has been utilised where adverse effects are likely (before mitigation) but the significance of effect would depend on site-specific factors.

B11.1 Future baseline conditions

Potential future baseline conditions relevant to land use and community are described in Appendix A for this theme. These potential future conditions are too complex/uncertain to allow an assessment to be made at this stage.

B12 Waste

Note on waste quantities:

The table below refers to excavated materials as the principal waste material produced by development of the GDF.

The updated illustrative designs [9] provide the following quantities for excavated materials (for the upper inventory):

- Higher strength rock – 10.80 million m^3
- Lower strength sedimentary rock – 8.83 million m^3
- Evaporite rock – 6.52 million m^3

Not all excavated material will necessarily become waste, as some will be used on site to form mounds (except evaporite rock), some will be used for backfill (higher strength rock only) and some may find a market for beneficial uses elsewhere.

Table B12 Waste

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Minimise the generation of waste and promote the application of and adherence to the waste management hierarchy.		
Siting process	A range of wastes would be generated during surface-based site investigations. It is anticipated that from a combined drilling of 25,000 m (from 20 deep boreholes) there would be up to 600 m^3 of drill cuttings (not the retrieved core), up to 1,800 m^3 of drilling fluid, up to 2,100 m^3 of test water and up to 3,000 m^3 of construction waste. It is also anticipated that there will be an increase in waste generated from machinery lubricants, oils and greases, excess cement from casing installations, fuels and component packaging. Some general office waste, organic canteen wastes, packaging and electrical products are likely to be	-	**Mitigation** During site-based investigations, implement waste minimisation and management best practices, in line with published guidelines and an environmental management plan incorporating a site waste management plan Consider materials usage and waste early and seek opportunities to design out waste generation. Opportunities may exist to minimise the generation of waste and promote the application

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	generated throughout the duration of the siting process. Drill cuttings (rock) would be disposed of to landfill after all required testing and analysis was complete[7]; Depending on their type, wastes may be sent to landfill, recycled or re-used. Some waste (for example small amounts of laboratory waste) may be treated as hazardous waste in line with relevant waste regulations.		of and adherence to the waste management hierarchy locally through community investment **Monitoring** Monitoring in relation to waste generation and adherence to the waste management hierarchy will be a continuous ongoing activity **Enhancement** Explore opportunities for beneficial re-use of drilling cuttings (for example re-use as secondary aggregate). Consider commercial, technical and environmental factors
Initial construction and underground based investigation	The construction of the GDF will generate large amounts of construction wastes: • Green waste from site clearance • Aggregates of varying size and composition, soil and spoil • The most significant waste stream would be excavated rock (see '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	- -	**Mitigation** Implement waste minimisation and management best practices, in line with published guidelines. The waste collection/management facilities at the site would be designed to facilitate the separation and re-use/recycling of waste Opportunities for the beneficial re-use of any surplus excavated rock should be explored at an early stage to maximise the likelihood of diverting the excavated rock/aggregates from landfill. For example, excavated rock could be exported via railhead for use as aggregates/construction material. There may also be opportunities for re-

[7] Shallow ground investigations may be required on brownfield sites. If so, there is the potential for small quantities of contaminated material to be encountered that may need to be disposed of as hazardous waste. This would not affect the majority of the volume of the drill cuttings, and is unlikely to occur on greenfield sites

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	• Tertiary wastes would include broken bricks/blocks, nails/bolts, worn tools, canisters, drums (for example fuel, diesel, and chemicals), ventilation filters, old vehicles and food waste and food packaging from on-site food consumption • Potential increase in general office and domestic waste such as paper, organic canteen waste, packaging and possibly some electrical waste (replacement and upgrades of computers) • Waste from the construction of associated infrastructure (for example access roads, railhead) Wastes may be sent to landfill, recycled or re-used, for example for landscaping or as aggregates for construction projects. Some of the waste may be treated as hazardous waste and would need to be handled in compliance with relevant waste regulations. The types of wastes generated would be similar for the different host rock types. However, the quantities of waste arising would vary, with evaporite having the greatest surplus excavated rock. Construction of the GDF within lower strength sedimentary rock could generate greater volumes of waste excavated rock due to fewer potential opportunities for re-use.		use of some excavated rock as hardcore or aggregate or for other purposes in construction of the GDF surface facilities **Monitoring** Monitoring in relation to waste generation and adherence to the waste management hierarchy will be a continuous ongoing activity Prepare, implement and periodically review a new environmental management plan(s) linked to an integrated waste management strategy All movements of waste from the site would be documented and recorded Targets would be set to divert a proportion of construction waste from landfill, focusing on the main waste types Quantities and types of waste would be monitored and performance against diversion targets would be regularly assessed Where it is not feasible to divert excavated rock/aggregates from landfill, the impact of waste from the construction of the GDF on existing waste management infrastructure would be assessed **Enhancement** Opportunities may exist to minimise the generation of waste and promote the application of and adherence to the waste management hierarchy locally through community investment

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	For all of the host rock types, if none of the surplus excavated rock could be re-used on or off-site for another purpose this would result in a significant waste stream. This could have a significant impact on existing waste management infrastructure.		
Ongoing construction and operation	Construction of the ILW/LLW vaults and HLW/SF disposal tunnels would continue throughout the operational period. The principal waste would be excavated rock. Other wastes similar to those listed above may also continue to be generated. Excavated evaporite rock may have some potential for beneficial reuse off-site. This is particularly the case for 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. Wastes may be sent to landfill, recycled or re-used, or treated as hazardous as stated above. The quantities of waste arisings would probably vary for the different host rock types as stated in the construction phase. Although evaporite rock would produce the highest quantities of surplus excavated rock, it is of high commercial value and can be used off site rather than discarded. Lower strength sedimentary rock is of lesser commercial value and as such generates more waste for disposal.	- -	**Mitigation** Implement waste minimisation and management best practices, in line with published guidelines The waste collection/management facilities at the site would be designed to facilitate the separation and re-use/recycling of waste Opportunities to be sought for beneficial / sustainable re-use of surplus excavated rock removed from site to avoid disposal as waste **Monitoring** Prepare implement and periodically review a new, operational-period environmental management plan incorporating a waste management strategy Targets would be set to divert a proportion of operational waste from landfill, focusing on the main waste types. All movements of waste from the site would be documented and recorded Quantities and types of waste would be monitored and performance against diversion targets would be regularly assessed. Where it is not feasible to divert excavated rock/aggregates from landfill, the impact of waste from the construction of the GDF on existing waste management infrastructure

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
			would be assessed **Enhancement** Opportunities may exist to minimise the generation of waste and promote the application of and adherence to the waste management hierarchy locally through community investment
Closure	A range of construction and general office waste arisings would be generated, similar to those mentioned in the construction phase summary. No further excavations would take place and therefore no further disposal of excavated rock waste would be required. The principal source of waste generation would be the decommissioning and demolition of surface facilities and the disposal of the relevant waste arisings. A proportion of the waste materials may be classed as hazardous wastes, which would be disposed of in licenced facilities in accordance with appropriate regulatory requirements (as they stand at the time).	-	**Mitigation** The integrated waste management strategy would consider the options for re-use or recycling of materials wherever possible, including the pre-closure audit to make the most of the opportunities available at that time. This could include supply of 'waste' materials from the GDF site to other construction sites elsewhere. Opportunities to be sought for beneficial / sustainable re-use of surplus materials to avoid disposal as waste both during closure. **Monitoring** Prepare, implement and periodically review a new, closure-period environmental management strategy Targets would be set to divert a proportion of waste from landfill focusing on the main waste types. **Enhancement** Opportunities may exist to minimise the generation of waste and promote the application of and adherence to the waste management

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
			hierarchy locally through community investment

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

B12.1 Future baseline conditions

Potential future baseline conditions relevant to waste are described in Appendix A for this theme. These potential future conditions may contribute positively to the extent to which the development of the GDF will achieve the environmental objective.

B13 Resource use, utilities and services

Table B13 Resource use, utilities and services

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
Environmental objective	Encourage and promote the efficient use of resources (materials, aggregates, metal). **Note:** The GDF will consume large quantities of materials throughout its construction, operation and closure phases; however, it should be noted that the objective relates not to the avoidance of using resources but the efficient use of resources, so that requirements are kept to the minimum actually needed.		
Siting process	A range of resources, utilities and services would be required during the surface-based site investigations, including: • Electricity • Water supplies • Communication systems Diesel generators may be used as the primary source of electricity if suitable mains connections do not exist, or the local mains supply is deemed to be unreliable. The use of these items would draw on finite resources such as fossil fuels and water and contribute towards effects under a number of other themes, including the water environment, air quality and climate change. However, the quantities involved are small and the effect is not considered significant.	-	**Mitigation** The type and quantity of resources, utilities and services required for construction would be considered at an early stage to allow for resource efficiency opportunities to be investigated. Design all site buildings and operations to high standards of energy and water efficiency, with reference to BREEAM or other relevant published standards. Reduce wastage through effective procurement. Use/specify materials with high recycled content and inherently low embedded carbon content and responsibly sourced. **Monitoring** Apply an appropriate environmental management plan Establish recording and monitoring procedure for use of resources, utilities and services during construction and set appropriate targets for performance (including targets for use of

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
			renewable energy) **Enhancement** Opportunities will exist to promote the efficient use of resources to GDF staff Opportunities may exist to promote the efficient use of resources locally through community investment
Initial construction and underground based investigation	Significant quantities of construction materials would be required. Indicative quantities for certain key materials are given below, based on generic design work [9] (note: quantities are for the whole life cycle of the GDF, not the construction phase alone): • Surface facilities concrete: between 41,791 – 44,779 tonnes • Surface facilities steel: between 1,456-1,792 tonnes • Surface facilities brickwork/blockwork: between 130-144 tonnes • Surface facilities cladding: between 23,233-25,688 tonnes • Underground concrete –890,000 m^3 (not including shotcrete) • Underground shotcrete –1,200,000 m^3 • Steel reinforcement – 3,000 tonnes • Rock bolts 5,000 tonnes required Additional materials would include explosives, general building materials, large quantities of steel for any new	-	**Mitigation** Apply all siting process mitigation measures at larger scale to construction process The type of and quantity of resources utilities and services required for construction would be considered at an early stage to allow for resource efficiency opportunities to be investigated Maximise the use of renewable energy sources Use non-potable water for construction operations. **Monitoring** Design, implement and periodically review and update a new environmental management plan for this phase Establish recording and monitoring procedure for use of resources, utilities and services and set appropriate targets for performance (including targets for use of renewable energy) **Enhancement** Opportunities will exist to promote the efficient use of resources to GDF staff Opportunities may exist to promote the efficient

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	rail infrastructure. These quantities initially appear large, but in the context of the capacity of relevant UK/international supply and the fact that the demand is spread over many years, the effect is not considered significant. Key utilities and services that would be required include: • Electricity • Water supplies • Ventilation systems for underground workings • Communication systems Depending on consumption, there may be a requirement for new or additional utilities and services provision. Energy use would increase through the construction phase (operation of plant machinery and equipment; heating, lighting, ventilation and electronics of site infrastructure) It is assumed that most energy demand would be met from the National Grid, with diesel generator backup. Water would be required for use in construction (for example for dust suppression, drilling fluid and cleaning machinery) and for domestic purposes as well as toilet and washing facilities (see 'Water' topic). Sewerage systems for treatment of wastewater may also be required, depending on whether there is opportunity to connect to the existing network. Resource use would vary between the different host		use of resources locally through community investment

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	rock types: • Concrete/shotcrete use would be greatest for a lower strength sedimentary rock site • Higher strength rock would require least steel reinforcement/rock bolts • Evaporite rock would require the most rock bolts Energy use to power plant could be greater where tunnel boring machines, road headers and continuous miners are utilised, as opposed to drill and blast methods. However, construction of the GDF within higher strength rock may require a greater quantity of plant and machinery which would have to be more hard wearing. The use of these items would draw on finite resources such as fossil fuels and water and contribute towards effects under a number of other themes, including the water environment, air quality and climate change. It should be noted, however, that the development of the GDF, although it would use large quantities of materials, intrinsically promotes the efficient use of materials; in that the GDF will be built and used only once, whereas any existing or new alternative surface facility would require ongoing maintenance and periodic reconstruction over a long timescale.		
Ongoing construction and	Key utilities and services include: • Electricity	-	**Mitigation** In addition to the continuation of the above, where appropriate:

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
operations	• Water supplies • Ventilation systems for underground workings • Communication systems Water would be required as described in construction phase above. Construction and subsequent backfilling of the ILW/LLW vaults and HLW/SF disposal tunnels would use greatest level of material resources. Emplacement of waste would commence during this phase and would be followed by the start of backfilling and sealing. Indicative quantities of backfill and related materials are given below (covering the whole operational and closure periods): • Bentonite – potentially between 0.66 and 4.4 million m^3, depending on rock type • Nirex Reference Vault Backfill – potentially around 1.7 million m^3 (higher strength rock only. • Cementitious grout – potentially around 1.85 million m^3 (lower strength sedimentary rock only) • Magnesium oxide – 6,930 m^3 (evaporite rock only) • Crushed rock– 1.27 million m^3 (evaporite rock only) Again, while the quantities at first seem large, the demand is spread over around 100 years, and in the		Design the GDF to maximise the potential for re-use of excavated rock in backfill in place of imported and specialist materials such as bentonite. Maximise use of renewable energy sources during operation. **Monitoring** Design, implement, periodically review and update a new environmental management plan for this phase Establish recording and monitoring procedure for use of resources, utilities and services during operation and set appropriate targets for performance (including targets for use of renewable energy) **Enhancement** Opportunities will exist to promote the efficient use of resources to GDF staff Opportunities may exist to promote the efficient use of resources locally through community investment

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	context of the relevant UK and international supply the effect is not considered significant. Note comments on efficiency under the construction phase above.		
Closure	During the closure and post-closure phase, significant quantities of backfill material would be required for mass backfilling of the underground facilities and roadways and similar key utilities, services and energy use would be required as above. Mass backfill quantities would be as follows: • Crushed rock: 3.8-4.5 million m^3 • Sand: 3.9 million m^3 (lower strength sedimentary rock only) • Bentonite: 1.7 million m^3 (lower strength sedimentary rock only) Water requirements would be as described in the construction phase above. The level of utilities and resources requirements would generally be lower than in previous phases and would decline as the phase proceeds. Extent of resource use would vary between the different host rock types: • For higher strength and evaporite rock types, excavated rock stored on site would be used for at least part of the backfill material • For lower strength sedimentary rock, all backfill	-	**Mitigation** Plan closure to maximise the potential for re-use of excavated rock in backfill in place of imported and specialist materials such as bentonite Maximise use of renewable energy sources **Monitoring** A new environmental management plan will be required. Periodic review and update of the environmental management plan. Establish recording and monitoring procedure for use of resources, utilities and services and set appropriate targets for performance. Set targets for use of renewable energy **Enhancement** Opportunities will exist to promote the efficient use of resources to GDF staff during closure Opportunities may exist to promote the efficient use of resources locally through community investment

Phase	Summary of the extent to which development of the GDF will contribute to achieving the environmental objective	Score without mitigation	Potential mitigation measures, monitoring principles and opportunities for enhancement
	would have to be imported to site For higher strength rock, a proportion of the crushed rock component of backfill could be met from rock stored on site in mounds. Similarly, there could be a covered store of evaporite rock on site for this purpose. However, it is anticipated that a significant proportion would need to be imported. Mass backfill material resource requirements could be greater for the lower strength sedimentary rock type as all this would need to be imported. The use of these items would draw on finite resources such as fossil fuels and water and contribute towards effects under a number of other themes, including the water environment, air quality and climate change. However, while the quantities seem large, the demand is spread over many years and in the context of the relevant UK and international supply the effect is not considered significant. Note comments on efficiency under the construction phase above.		

Key to the assessment of impact	x Not scored	N Neutral / negligible	+ Minor positive effect	++ Major positive effect	- Minor negative effect	- - Major negative effect

B13.1 Future baseline conditions

Potential future baseline conditions relevant to resource use, utilities and services are described in Appendix A for this theme. These potential future conditions are too complex/uncertain to allow an assessment to be made at this stage.

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