

# Geological Disposal

## Science and Technology Programme

May 2016





# Geological Disposal

## Science and Technology Programme

**May 2016**

## **Conditions of Publication**

This report is made available under the Radioactive Waste Management Limited Transparency Policy. In line with this policy, Radioactive Waste Management Limited is seeking to make information on its activities readily available, and to enable interested parties to have access to and influence on its future programmes. The report may be freely used for non-commercial purposes. However, all commercial uses, including copying and re-publication, require permission from the Nuclear Decommissioning Authority (NDA). All copyright, database rights and other intellectual property rights reside with the NDA. Applications for permission to use the report commercially should be made to the NDA Information Manager.

Although great care has been taken to ensure the accuracy and completeness of the information contained in this publication, the NDA cannot assume any responsibility for consequences that may arise from its use by other parties.

© Nuclear Decommissioning Authority 2016. All rights reserved.

ISBN 978-1-84029-528-3

## **Bibliography**

If you would like to see other reports available from Radioactive Waste Management Limited and the NDA, a complete listing can be viewed at our website, or please write to our Communications department at the address below.

## **Feedback**

Readers are invited to provide feedback to the Radioactive Waste Management Limited on the contents, clarity and presentation of this report and on the means of improving the range of reports published. Feedback should be addressed to:

RWM Feedback  
Radioactive Waste Management Limited  
Building 587  
Curie Avenue  
Harwell Oxford  
Didcot  
OX11 0RH  
UK

email [rwmfeedback@nda.gov.uk](mailto:rwmfeedback@nda.gov.uk)

## **Foreword**

We are delighted to introduce this new issue of our Science & Technology Programme covering RWM's science and technology work. The programme has been significantly restructured to take account of developments in Government policy and in our own organisation.

In April 2014, the Nuclear Decommissioning Authority (NDA) established RWM as a wholly-owned subsidiary with the purpose of delivering a geological disposal facility (GDF) and providing solutions for the management of higher activity radioactive waste.

The Government set out its priorities and timescales in its 2014 White Paper *Implementing Geological Disposal*. Since then RWM has published its Corporate Strategy setting out how RWM will achieve its goals, and this Science & Technology (S&T) Programme provides the bridge that links the company's technical work to the strategy.

This document provides a concise overview of the structure and scope of technical work that RWM plans to carry out and of the key outputs to be produced to support delivery of a GDF and the provision of waste management solutions. This Science & Technology Programme therefore provides an excellent introduction to the technical activities being undertaken prior to GDF construction.

The accompanying Science & Technology Plan describes the detailed projects which fulfil the work set out in general terms in the Programme.

**John Corderoy**, Science and Technology Director

**Professor Cherry Tweed**, Chief Scientific Advisor

## Preface

Radioactive Waste Management Limited (RWM) is responsible for delivering a geological disposal facility (GDF) for the UK's higher activity radioactive wastes and for providing waste management solutions. RWM is progressing an iterative programme of specification, design, assessment and research and development (R&D) activities that will enable it to achieve its vision of “*A safer future by managing radioactive waste effectively, to protect people and the environment*”. The purpose of this document is to describe how RWM's Science and Technology (S&T) Programme is organised and what it involves.

Two previous versions of the S&T Programme (then called the “Technical Programme”) have been produced, in September 2013 and March 2014. Both were structured into three volumes, as follows:

- Part A provided an introduction, including high-level context, together with some information on the processes used to develop RWM's work programme. It explained how the work programme is structured, and summarised the alignment of key deliverables from packages of technical work, termed “Major Products”, with RWM's mission.
- Part B presented detailed descriptions of the Major Products, along with the frameworks, strategies and tools for delivering these products, called “Delivery Mechanisms”. Each Major Product and Delivery Mechanism description followed a systematic structure.
- Part C was a detailed description of the prioritised programme for R&D activities required to support the delivery of a GDF. It had previously been published as a separate document (the R&D Programme).

Several significant developments have taken place since Version 2 of the Technical Programme was produced:

- Establishment of RWM as a wholly owned subsidiary of the NDA on 1 April 2014.
- Publication of the July 2014 White Paper *Implementing Geological Disposal*.
- Publication of RWM's first S&T Plan on 2 September 2014<sup>1</sup>.
- Publication of RWM's Corporate Strategy for 2015 to 2018 on 14 May 2015.

The present document has been significantly restructured to reflect these developments. Key changes are as follows:

- RWM's Corporate Strategy sets out the framework within which RWM's scientific and technical work programme is carried out. It effectively replaces Part A from previous versions of the Technical Programme. Additional background and context to the S&T Programme is provided in the first three sections of this document.
- The S&T Plan presents detailed plans to deliver RWM's future generic R&D activities in support of its mission. It replaces RWM's R&D Programme and hence, also replaces Part C from previous versions of the Technical Programme as a separate, stand-alone companion document to the S&T Programme.

---

<sup>1</sup> Nuclear Decommissioning Authority, *Geological Disposal: Science and Technology Plan*, NDA Report no. NDA/RWM/121, Version 1, September 2014 (now superseded by Version 2).

The current version of the S&T Programme therefore builds largely on Part B from Version 2. After the background and context provided in Sections 1 to 3, it focuses solely on Major Product descriptions, which have been restructured and shortened, in order to improve clarity. Descriptions of individual Delivery Mechanisms are no longer included in the S&T Programme (although an explanation of the overarching programme structure and process for delivery *is* provided), so as to focus on the key deliverables that RWM needs to produce, rather than the detailed processes by which these deliverables are produced. Delivery Mechanisms are still documented within RWM's management systems and company / departmental strategy documents.

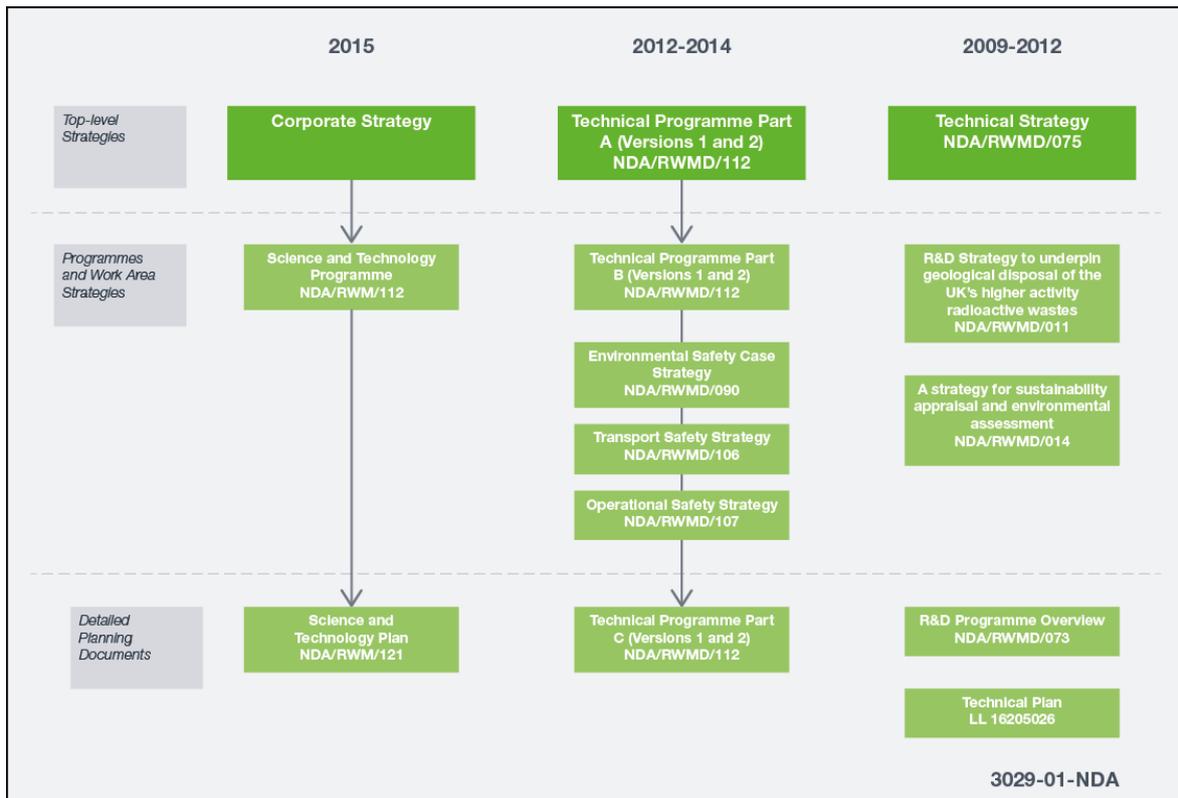
Detailed information on specific pieces of technical work that was previously included in the Technical Programme has now been incorporated into task sheets within a revised version of the S&T Plan, published at the same time as this document. Task sheets in the S&T Plan build on the descriptions of Major Products in this document, and provide details of specific pieces of work within a programme of generic R&D activities that are planned in the next ten years. The planned work set out in each task sheet may support one or more Major Products, as identified in the S&T Plan.

Clearly, the suite of documents reflecting RWM's strategy, programme and latest planning across its science and technology work programme has evolved significantly over the last few years. Figure P1 summarises various RWM strategy, programme and planning documents that were published between 2009 and 2014, but which are now out of date. These have been superseded by RWM's Corporate Strategy, S&T Programme (this document), and S&T Plan.

The S&T Programme will be reviewed and updated periodically, to reflect RWM's activities as development and implementation of a GDF progresses. Feedback on this document would be welcomed, particularly on the scope of the work programme presented here (and in the S&T Plan), and on the clarity of presentation. Contact details for providing feedback can be found in the Conditions of Publication at the front of this document.

**Figure P1 Current and superseded RWM strategy, programme and planning documents**

The current hierarchy of documents setting out RWM’s S&T work programme is shown on the left in beige boxes. Related, superseded documents are shown in green boxes. The safety strategies previously existed alongside the Technical Programme Part B. They are now partially superseded by the Science and Technology Programme. In addition, some of their detailed content is now captured in a series of safety manuals that form part of RWM’s quality management system



## List of contents

<b>Foreword</b>	<b>iii</b>
<b>Preface</b>	<b>iv</b>
<b>List of figures (excluding those within Major Product descriptions)</b>	<b>viii</b>
<b>List of acronyms and abbreviations used in this report</b>	<b>ix</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Background	1
1.2 Purpose and Objectives of the S&T Programme	1
1.3 RWM's Hierarchy of Strategy, Programme and Planning Documents	1
1.4 Structure of the S&T Programme	2
1.5 Further Development of the S&T Programme	3
<b>2 Structure of RWM's S&amp;T Programme and process for delivery</b>	<b>4</b>
2.1 Iterative development process	4
2.2 Organisation of the S&T Programme	5
2.3 Process for identification, planning and delivery of the S&T Programme	8
2.4 Generic and site-specific work streams	9
2.5 Timescales for delivery of Major Products	10
<b>3 Delivery of RWM's S&amp;T Programme</b>	<b>13</b>
3.1 Role of Major Products	13
3.2 Structured summary of Major Products in each work area	14
3.3 Structure of Major Product descriptions	18
3.4 Summary of Major Products	18
3.5 Current status of RWM's S&T programme	21
<b>4 Major Products in the disposal system specification (DSS) work area</b>	<b>22</b>
<b>5 Major Products in the disposal system design work area</b>	<b>33</b>
<b>6 Major Products in the assessments work area</b>	<b>53</b>
<b>7 Major Products in the underpinning knowledge base work area</b>	<b>95</b>
<b>8 References</b>	<b>128</b>

## List of figures (excluding those within Major Product descriptions)

Figure 1	Hierarchy of documents setting out RWM's S&T work programme	2
Figure 2	RWM's iterative development process	4
Figure 3	Organisation of the S&T Programme illustrating the hierarchy of scientific and technical work areas that fall within RWM's iterative development process	7
Figure 4	Process for identification, planning and delivery of the S&T work programme	9
Figure 5	Phases in the development of a GDF and link to terminology used in the S&T Programme to describe the timing for the production of Major Products	12
Figure 6	S&T Programme – indicative profile of work	14
Figure 7	Example product breakdown diagram	16
Figure 8	Example indicative schedule showing the timescales for production of Major Products in the disposal system design work area	17
Figure 9	Summary of RWM's Major Products and the associated descriptions provided in the S&T Programme	19
Figure 10	Timeline for the evolution of RWM's knowledge base, with examples of current research priorities	21
Figure 11	Excerpt from the DSTS illustrating the approach to specify and justify requirements on the disposal system	23
Figure 12	Product breakdown structure for the DSS work area	24
Figure 13	Indicative schedule for the production of Major Products in the DSS work area	24
Figure 14	Product breakdown structure for the disposal system design work area	33
Figure 15	Indicative schedule for the production of Major Products in the disposal system design work area	34
Figure 16	Product breakdown structure for the assessments work area	54
Figure 17	Indicative schedule for the production of Major Products in the Assessments work area	55
Figure 18	S&T-based R&D topic areas	96
Figure 19	Product breakdown structure for the underpinning knowledge base work area	97
Figure 20	Indicative schedule for the production of Major Products in the underpinning knowledge base work area	98

## List of acronyms and abbreviations used in this report

AGR	Advanced Gas-Cooled Reactor
ALARP	As Low As Reasonably Practicable
AS	Assessments
ATR	Annual Technical Report
BAT	Best Available Technique
BIOMASS	BIOsphere Modelling and ASSessment
CAST	Carbon-14 Source Term
CDM 2015	Construction (Design and Management) Regulations 2015
CNS	Civil Nuclear Security
CoRWM	Committee on Radioactive Waste Management
DE	Disposal System Design
DECC	Department of Energy and Climate Change
DMS	Data Management System
DNLEU	Depleted, Natural and Low-Enriched Uranium
DSDS	Disposal System Design Specification
DSFS	Disposal System Functional Specification
DSS	Disposal System Specification
DSSC	Disposal System Safety Case
DSTS	Disposal System Technical Specification
EC	European Commission
EDZ	Excavation Damaged Zone
EIA	Environmental Impact Assessment
ERICA	RWM's Non-Human Biota Model
ESC	Environmental Safety Case
ESM	Environmental Safety Manual
FORGE	Fate of Repository Gases
GDF	Geological Disposal Facility
gDSSC	Generic DSSC
HAW	Higher Activity Waste
HEU	High-Enriched Uranium
HRA	Habitats Regulations Assessment
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
ISE	Initial Site Evaluation
KB	Underpinning Knowledge Base
LASGIT	Large-Scale Gas Injection Test
LLW	Low Level Waste
LoC	Letter of Compliance
LTP	Lifetime Plan

MoDeRn	Monitoring Developments for Safe Repository Operation and Staged Closure
MRWS	Managing Radioactive Waste Safely
NDA	Nuclear Decommissioning Authority
NERC	Natural Environment Research Council
NOSM	Nuclear Operational Safety Manual
NSIP	Nationally Significant Infrastructure Projects
OESA	Operational Environmental Safety Assessment
ONR	Office for Nuclear Regulation
OSC	Operational Safety Case
PDSR	Package Design Safety Report
PEI	Preliminary Environmental Information
PESE	Preliminary Environmental Safety Evaluation
PIP	Provisional Implementation Plan
PVP	Property Value Protection
PWD	Process Wiring Diagrams
PWR	Pressurised Water Reactor
QMS	Quality Management System
R&D	Research and Development
RMS	Requirements Management System
RSC	Robust Shielded Container
RWM	Radioactive Waste Management Limited
S&T	Science and Technology
SDM	Site Descriptive Models
SLC	Site Licence Company
SP	Disposal System Specification
SSSIs	Sites of Special Scientific Interest
SWPD	Standard Waste Package Description
SWTC	Shielded Waste Transport Container
TBuRD	Technical Baseline and Underpinning Research and Development
THMCB	Thermal, Hydrogeological, Mechanical, Chemical and Biological
TMS	Technical Management Summary
TPS	Transport Package Safety
TSC	Transport Safety Case
TSD	Transport System Design
TSM	Transport Safety Manual
TSSA	Transport System Safety Assessment
UKRWI	United Kingdom Radioactive Waste Inventory
URL	Underground Research Laboratory
WAC	Waste Acceptance Criteria

# S&T Programme – Introduction

---

## 1 Introduction

### 1.1 Background

The Nuclear Decommissioning Authority (NDA) is making good progress in dealing with the UK's nuclear legacy and is bringing the very best skills and expertise from around the world to do this safely and in the most efficient and cost-effective way. A key part of dealing with this legacy is the management of higher activity radioactive waste [1] and its eventual disposal. A Geological Disposal Facility (GDF) is a vital final piece in the decommissioning programme. In pursuit of that, NDA established Radioactive Waste Management Limited (RWM) as a wholly owned subsidiary on 1 April 2014, whose mission is to deliver a GDF and provide radioactive waste management solutions.

RWM's vision is "*A safer future by managing radioactive waste effectively, to protect people and the environment*". In order to achieve this, RWM will work with the producers of radioactive waste to provide packaging solutions that ensure that the waste can be stored, and eventually, disposed of, in a safe and cost-effective way.

RWM has a key role as the NDA's delivery body for developing a GDF. That role, and the process for siting a GDF, is set out in the July 2014 White Paper *Implementing Geological Disposal* [2]. The process set out in the White Paper for finding and developing a site for a GDF is based on the principle of working with communities that are willing to participate in this process.

In May 2015, RWM published its first Corporate Strategy [3]. This sets out RWM's vision, mission and values, and identifies RWM's key strategic drivers.

This document, entitled the Science and Technology (S&T) Programme, describes the programme of scientific and technical work that RWM will carry out and the main deliverables it will produce, in support of its Corporate Strategy. It is part of a hierarchy of documents that sets out RWM's approach to carrying out the scientific and technical work required to support delivery of a GDF and the provision of waste management solutions.

### 1.2 Purpose and Objectives of the S&T Programme

The primary audience of the S&T Programme is RWM's external stakeholders. With this in mind, the document describes:

- The structure and scope of RWM's scientific and technical work (across all departments and work areas).
- The key outputs to be produced in support of RWM's mission.

The S&T Programme will also be used as a management tool within RWM to help:

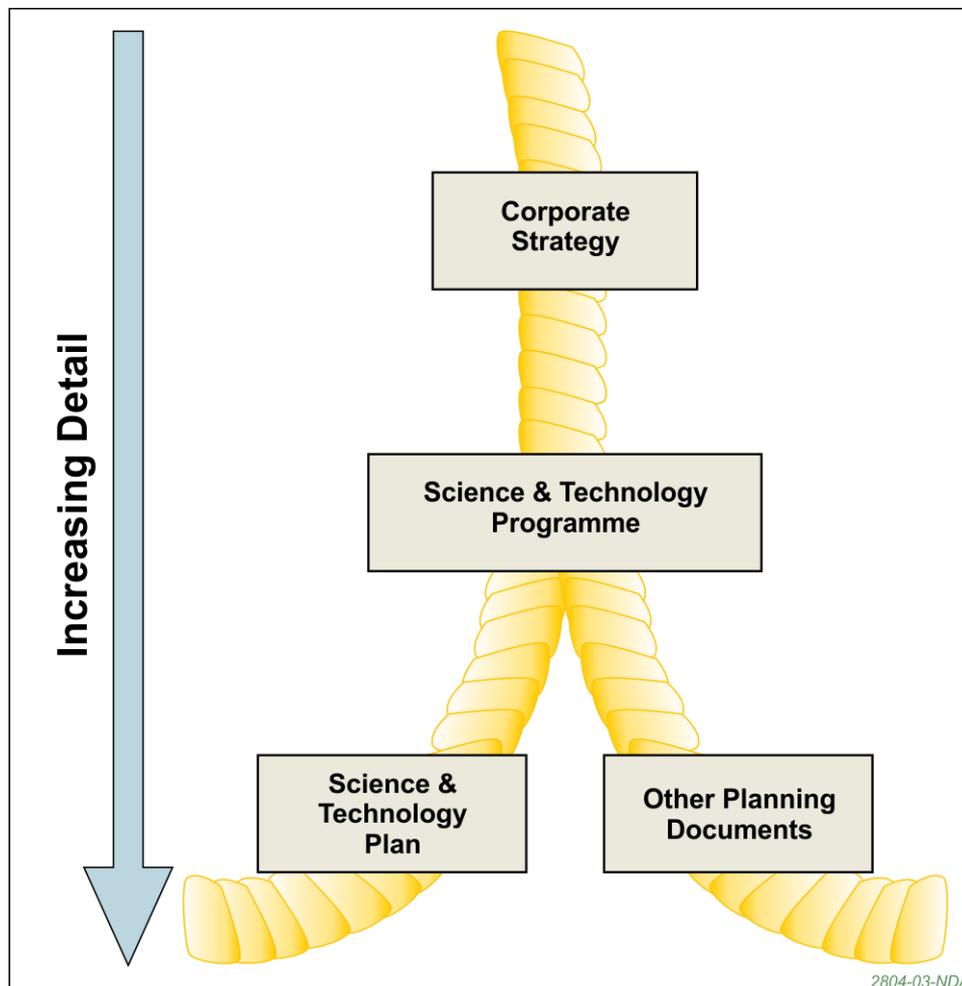
- Plan RWM's near-term work programme and associated internal resourcing.
- Identify areas of the work programme that require further development and planning.
- Enable a completeness check on the programme to provide confidence that all technical aspects of RWM's remit are being addressed.

### 1.3 RWM's Hierarchy of Strategy, Programme and Planning Documents

Various documents reflecting RWM's strategy, programme and detailed plans for its S&T work programme were published between 2009 and 2014, as described in the preface to this document. These are superseded by the hierarchy of documents set out in Figure 1, comprising RWM's Corporate Strategy, its S&T Programme (this document) and its S&T Plan, Version 2 of which was published alongside this document [4].

## S&T Programme – Introduction

**Figure 1** Hierarchy of documents setting out RWM’s S&T work programme  
Collectively, these documents provide the “golden thread” linking RWM’s vision, mission and values to detailed S&T work plans across RWM’s programme



Other RWM planning documents, besides the S&T Plan, also sit below the S&T Programme as shown in this figure, supporting the delivery of Major Products by detailing aspects of how they will be produced, along with supporting work that is, or will be, required. Some of these planning documents have already been produced, and are maintained internally by RWM. Others will be produced in future as part of planning the detailed delivery of upcoming Major Products. RWM’s planning documents will be updated as necessary and others, besides the S&T Plan, may be published in future, to aid communication, or if there is a need for stakeholder engagement to inform their development.

### 1.4 Structure of the S&T Programme

The rest of this document has the following structure:

- Section 1 explains how RWM’s S&T work programme is structured, based on an iterative business model for development and implementation, and describes how the programme is organised through the delivery of Major Products. It outlines RWM’s generic and site-specific work streams and describes how timescales for delivery of

## S&T Programme – Introduction

---

Major Products are aligned to three phases of activity: preparatory studies, surface-based investigations, and construction and underground-based investigations.

- Section 3 discusses the role of Major Products and explains the systematic structure of Major Product descriptions used throughout the rest of this document. It also summarises the Major Products to be delivered by RWM during the preparatory studies phase and surface-based investigations phase of the GDF siting programme.
- Section 4 provides descriptions of the Major Products in the Disposal System Specification work area.
- Section 5 provides descriptions of the Major Products in the Disposal System Design work area.
- Section 6 provides descriptions of the Major Products in the Assessments work area.
- Section 7 provides descriptions of the Major Products in the Underpinning Knowledge Base work area.
- Section 8 contains a list of references cited in Sections 1 to 3. Major Product descriptions in Sections 4 to 7 are self-contained, and each description includes a list of references, if needed.

### 1.5 Further Development of the S&T Programme

The S&T Programme will continue to be updated periodically to reflect progress that has been made and major milestones achieved in the implementation of geological disposal. It is envisaged that this document will be used as an input to RWM's business planning cycle, since it provides a high-level overview of all of RWM's S&T activities in support of its mission. Such an approach enables the implications of progress with, and changes to, individual components of the programme to be identified and addressed.

RWM welcomes feedback from stakeholders on its S&T Programme. Specifically, stakeholders are invited to consider the scope of the work programme set out here, and in the S&T Plan [4], and the clarity of presentation, and to consider the following questions:

- Do the work areas described reflect the full scope of work that RWM needs to carry out? Have we left out a major area?
- Does the S&T work programme adequately capture the knowledge gaps, uncertainties and issues that need to be addressed in each area?
- Are there areas where you consider the proposed work programme to be inappropriate or inadequate?

In each case, please describe your reasons for making the comment, and, if there are additional sources of information that you would like to bring to RWM's attention, that would be very helpful.

Contact details for providing feedback can be found in the Conditions of Publication at the front of this document.

## S&T Programme – Structure

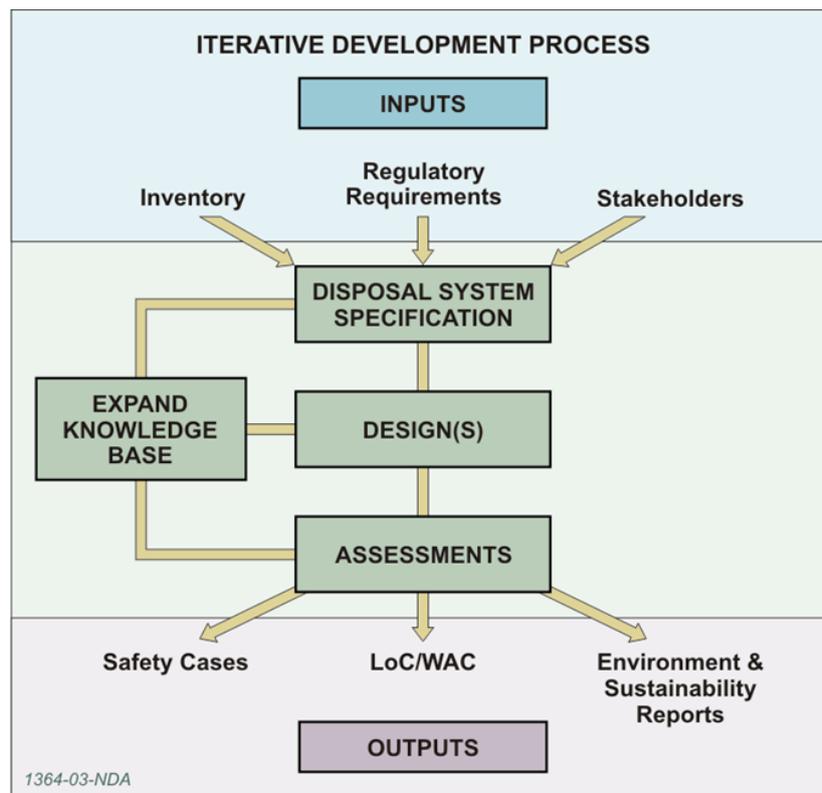
### 2 Structure of RWM's S&T Programme and process for delivery

#### 2.1 Iterative development process

RWM follows an iterative process to develop and implement its S&T work programme. The components of RWM's iterative development process are illustrated in Figure 2 and briefly described below.

**Figure 2 RWM's iterative development process**

The deliverable outputs from this process are **Major Products**



Development of the S&T work programme is a requirements-driven process. Broadly speaking, these requirements can be grouped into three types of inputs:

- The waste and waste packages that require disposal, i.e. the 'inventory' [1].
- Applicable regulatory requirements and permissions.
- Stakeholder requirements, discussed in RWM's strategy for public and stakeholder engagement and communication [5].

RWM uses these requirements to develop work that needs to be undertaken in the disposal system specification, disposal system design, assessments and knowledge base work areas. The scope of these work areas is as follows:

- The **Disposal System Specification (DSS)** sets out the requirements on the disposal system, including those imposed by regulators and stakeholders, as well as definitions of the nature and characteristics of the waste to be managed.
- Details of how the requirements and constraints set out in the DSS will be addressed are presented in **disposal system designs**. At present, a range of conceptual

## S&T Programme – Structure

---

designs is being considered which could be applied in one or more illustrative geological environments.

- **Assessments** of the safety and environmental protection provided by disposal system designs are carried out. The objectives of assessing safety are to understand and illustrate the range of possible behaviours of the disposal system, to build confidence in this understanding, and to identify knowledge gaps.
- Work required to **expand RWM's knowledge base** is carried out based on uncertainties and knowledge gaps identified in RWM's work programme, and is used to iteratively update aspects of the programme.

Various outputs are generated from assessment activities:

- The technical arguments and supporting numerical calculations demonstrating safety are presented in a series of **safety cases**, including the generic Disposal System Safety Case (DSSC) published in 2010 [6]. These consider the safety of radioactive waste transport, the safety of constructing and operating a GDF and the safety of the disposal facility in the long term, after it has been sealed and closed.
- RWM conducts the Letter of Compliance (**LoC**) disposability assessment process in order to provide guidance to Site Licence Companies (SLCs) on the measures that can be taken to convert higher activity wastes into a passively safe form ('packaged') whilst providing confidence that the packaged wastes will be transportable to, and disposable at, a future GDF.
- RWM also carries out environmental and sustainability assessment work. This is being undertaken at three progressively more detailed levels:
  - Generic assessments (i.e. not location-specific) are developed and maintained to help identify potential effects associated with implementing geological disposal. Such assessments are used to inform the development of design concepts for the disposal system, to support engagement with stakeholders and to support the early stages of the GDF siting process.
  - During the siting process, RWM will work with interested communities to discuss their concerns and opinions about hosting a GDF and to develop a better understanding of the implications of implementing geological disposal within their areas. This could involve undertaking community-specific assessments to explore potential environmental and sustainability effects in greater depth and in the context of known local conditions.
  - During the later stages of site selection RWM will undertake site-specific assessments (Environmental Impact Assessment for example). These will support progressively more detailed design work, decisions about the selection of a preferred site, and the statutory land-use planning process for surface-based investigations (boreholes) and, ultimately, for a GDF.

### 2.2 Organisation of the S&T Programme

The iterative development process described above has been used to identify and organise the deliverables from technical work packages, or "Major Products", that need completing in order to realise a GDF and to provide radioactive waste management solutions. The detailed breakdown of Major Products within each of the four main work areas (specifications, designs, assessments and underpinning knowledge) is illustrated in Figure 3; one or more Major Products will be produced under each of the lowest tier work areas. Each Major Product has been assigned a unique number, used throughout this document, composed of a two-letter identifier for the corresponding main work area ('SP' for disposal

## **S&T Programme – Structure**

---

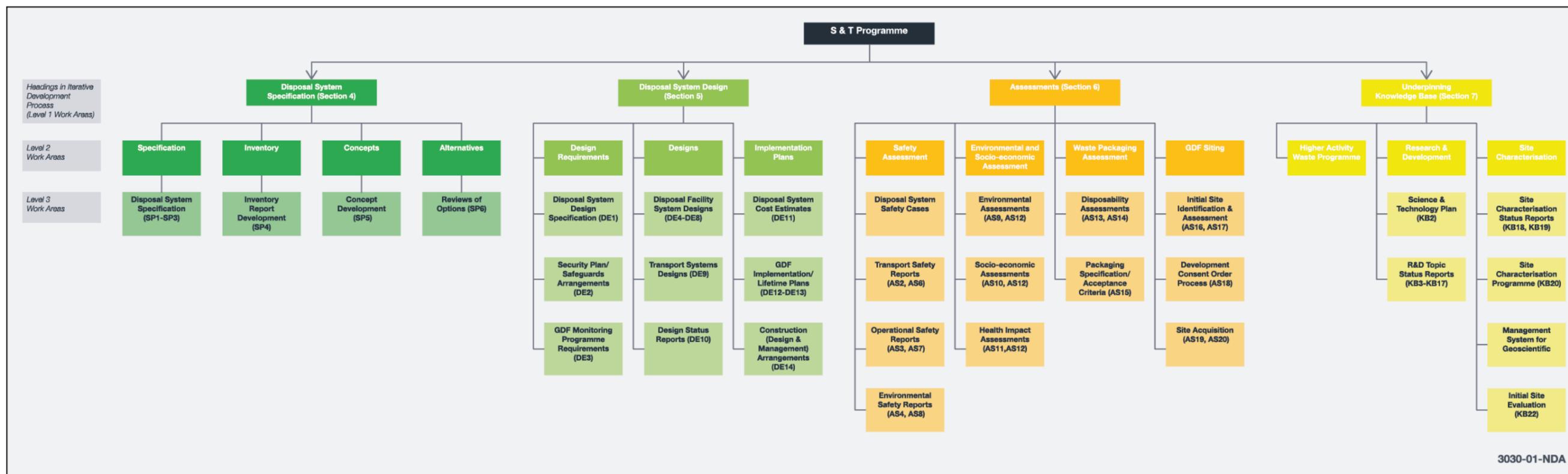
system specification, 'DE' for disposal system design, 'AS' for assessments and 'KB' for underpinning knowledge base) and a sequential number within that work area.

The structure of this document reflects this organisation of the technical work programme. Sections 4 to 7 describe the Major Products associated with the four main work areas.

## S&T Programme – Structure

Figure 3 Organisation of the S&T Programme illustrating the hierarchy of scientific and technical work areas that fall within RWM’s iterative development process

Cross references are provided to report sections covering each of the main (Level 1) work areas. Major Products discussed in this report are listed under the relevant lowest tier work area using the numbering convention described in Section 2.2



## S&T Programme – Structure

---

### 2.3 Process for identification, planning and delivery of the S&T Programme

RWM's overall process for identification and delivery of its S&T work programme is illustrated in Figure 4. Key steps are as follows:

- As explained in Section 2.1, RWM's iterative development process is **framed** by a number of external requirements and inputs, including the inventory requiring disposal [1], the 2014 White Paper [2], regulatory requirements, stakeholder views and interactions with the broader nuclear industry with respect to the lifecycle for radioactive waste management.
- These requirements and inputs are captured in the DSS and used as the framework from which the **drivers** for the work programme are identified. The DSS uses the concept of Safety Functions to identify the requirements on the various disposal system components.
- The information needed to meet the drivers is collated, prioritised and scheduled, resulting in the **development of RWM's S&T Programme**.
- Components of this programme are then **implemented** and delivered through a series of projects. External organisations with expertise in relevant fields are typically commissioned to deliver work under a project, generally following a competitive tendering exercise. Major Products are the key outputs from these projects, or are prepared based on the outputs of these projects.
- The outputs from completed work are **reviewed and evaluated**, and any changes considered through updating the knowledge base<sup>2</sup>.

RWM prioritises work under its S&T Programme based on the significance of the information need i.e. its potential impact on safety and/or delivery of RWM's mission, and the extent of the associated knowledge gap or uncertainty, as well as various scheduling considerations. Seven key questions are considered:

- What is the driver for the work?
- What needs to be known and by when?
- How important or significant is the topic area?
- What is the "knowledge gap"? This is defined as the gap between RWM's current understanding and the level RWM needs to acquire.
- What does RWM need to do to fill the knowledge gap?
- How long will this take? Factoring time considerations into the development of underpinning knowledge is particularly important where long-term experiments and demonstration studies are required, since these may need to run for timescales of a decade or more.

---

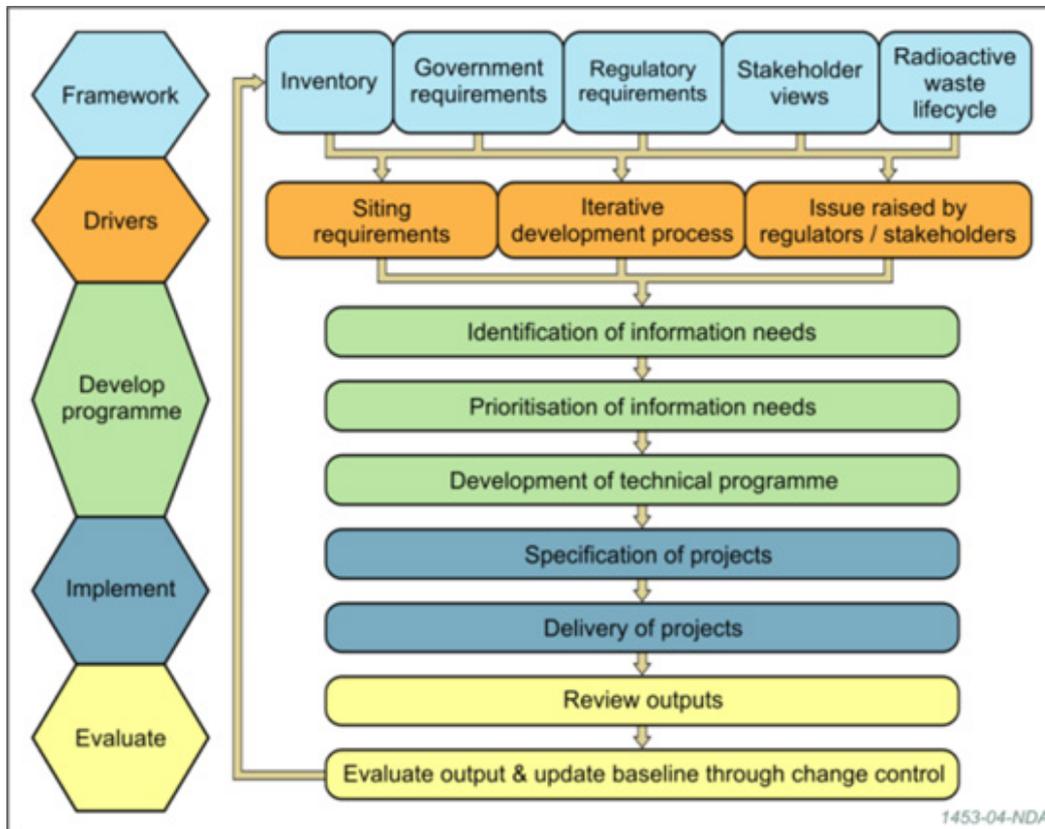
<sup>2</sup> The technical development of a GDF for disposal of the UK's higher activity radioactive waste is based on scientific, technological and engineering knowledge and expertise. A large number of documents underpin the technical basis for geological disposal, drawing together information from a wide range of radioactive waste management programmes undertaken both in the UK and internationally. This set of documents can be regarded as RWM's "knowledge base".

The knowledge base is continually updated. Changes to key documents (e.g. requirements, assumptions, data and methodologies) are controlled, where required, through a change management process.

## S&T Programme – Structure

- How urgent is the task? The urgency of a task is determined by taking account of the date when information is needed and the time required to obtain it.

**Figure 4 Process for identification, planning and delivery of the S&T work programme**



Other factors that are also considered when planning and prioritising work include:

- The need to maintain and develop the skills base within RWM and more widely in the nuclear industry.
- Appropriate sequencing of interdependent activities, both within a particular work area and across the whole S&T Programme.
- Providing sound packaging advice to waste producers.
- Responding to issues raised by the regulators and other external stakeholders.

### 2.4 Generic and site-specific work streams

RWM's work programme is currently in a generic phase, i.e. it does not consider any site-specific information. Once site-specific activities commence, separate generic and site-specific work streams will be maintained in parallel. The generic elements of the work programme do not stop when site-specific activities begin; they will continue until such time as there is sufficient confidence in site-specific activities to judge that generic activities are no longer required. This strategy ensures that there is always a well-developed baseline of knowledge and understanding to draw on, regardless of how GDF siting progresses. It also allows for the possibility of sites being put forward for consideration at any point, and enables RWM to undertake disposability assessments that encompass a broad range of potential GDF designs until such time as the site-specific waste acceptance criteria and associated safety case are sufficiently well established. Both generic and site-specific

## S&T Programme – Structure

---

activities could encompass desk-based studies and laboratory-based work, including participation in studies at overseas underground research laboratories (URLs).

Major Products can be categorised according to whether they are generic or site-specific in nature:

- Generic Major Products do not contain any site-specific information, and are therefore applicable to the GDF implementation programme regardless of the nature of sites identified and selected in the future. RWM's generic work programme reflects the importance of the continued development and maintenance of knowledge as its programme progresses.
- Site-specific Major Products are those that incorporate some element of site-specific information. No site-specific Major Products have been produced to-date, but those that have been identified as being required are described in this document.

### 2.5 Timescales for delivery of Major Products

Timescales for production of Major Products described in the S&T Programme have been aligned with three indicative phases of activity associated with the delivery of a GDF:

- **Preparatory studies** – during this phase RWM's work supports UK Government and communities who are interested in potentially hosting a GDF. RWM will work with interested communities by undertaking desk-based studies of any potential sites identified in their areas (supported by generic R&D). This phase includes the two-year period of initial actions set out in the 2014 White Paper [2] and may extend several years beyond this, depending on the progression of formal discussions with interested communities.
- **Surface-based investigations** – if communities continue their involvement in the siting process, surface-based site investigations will be carried out. At this time RWM will need to obtain the necessary environmental permits and planning permission to carry out borehole drilling to improve understanding of the local geology and to identify potential sites. The White Paper assumes that site investigations would be completed within a planning and engagement period lasting 15-20 years.
- **Construction and underground-based investigations** – Once RWM is satisfied that it has sufficient information to demonstrate that a site is suitable then, subject to a test of public support, the granting of development consent, and approval of the independent regulators, construction of a GDF could proceed. At this point RWM will seek planning and other relevant regulatory permissions. Procurement and contractual arrangements for construction of the GDF will be finalised. Underground investigations will be carried out to confirm the site is suitable.

The staged lifecycle of a geological disposal programme continues through **GDF operations** and **closure** phases, with the ultimate aim of ensuring that the waste is disposed of in a way that protects the health and interests of people and the integrity of the environment, at the time of disposal and in the future. Development and implementation of a GDF would need to proceed through these five phases of activity, whatever the details of the siting process and the progression of formal discussions with interested communities. The broad sequence for production of most Major Products is therefore not expected to change significantly, although exact timings are not certain.

The S&T Programme currently focuses on Major Products that have been developed, or will be developed during the preparatory studies phase and the surface-based investigations phase. Major Products to be delivered during the construction and underground-based investigations phase and beyond are generally not included, on the basis that details of what is required may evolve before these phases are reached. Future versions of the S&T

## S&T Programme – Structure

---

Programme will in due course provide descriptions of the full range of Major Products to be delivered after commencement of construction and underground-based investigations.

To aid planning with respect to the sequencing for production of Major Products, the S&T Programme divides the preparatory studies phase and surface-based investigations phase into several sub-phases as follows:

### **Preparatory studies:**

- “Current activities”, which reflect Major Products that RWM is currently preparing, or has already prepared.
- “Planned activities”, which cover the period of desk-based studies as part of RWM’s early to mid-preparatory studies phase.
- “Transitional activities”, which concern the delivery of Major Products towards the end of the preparatory studies phase, as desk-based studies are completed and as RWM prepares for surface-based investigations.

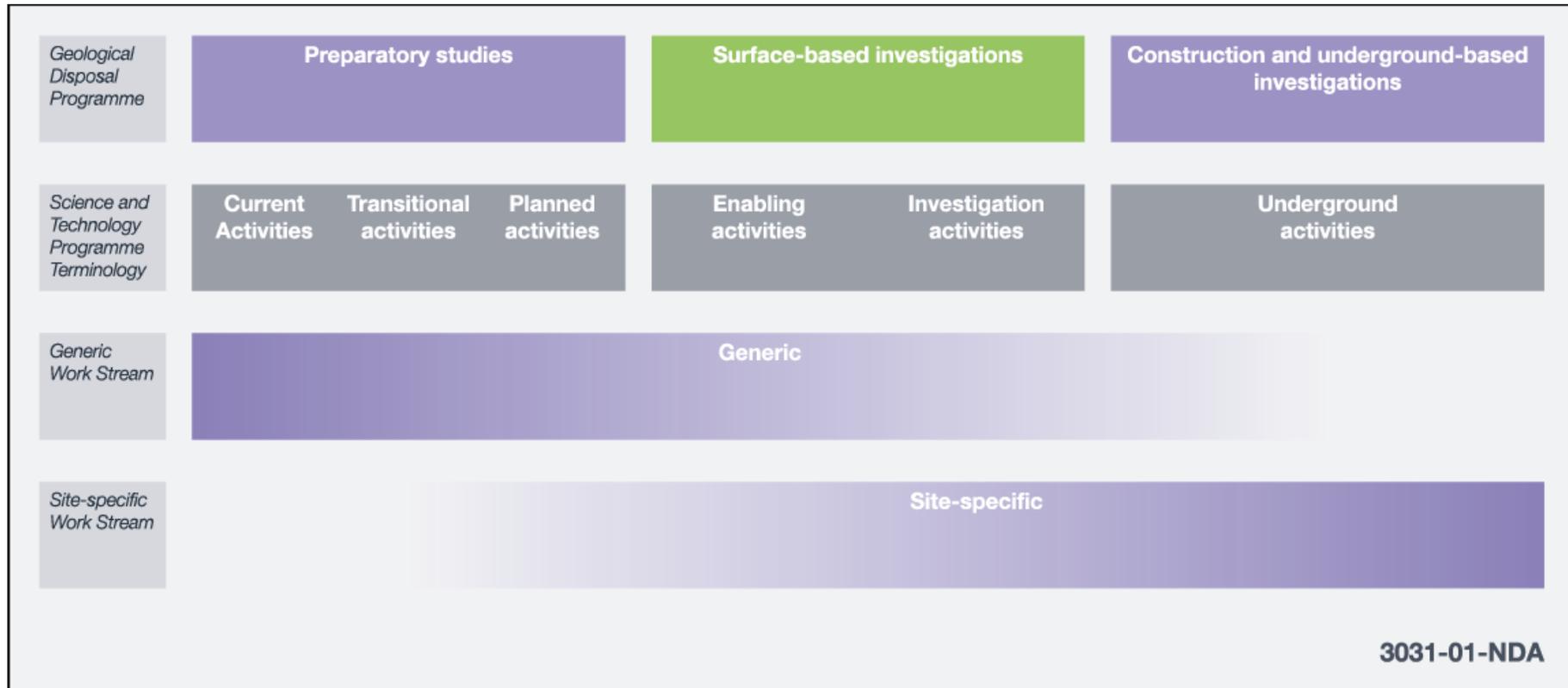
### **Surface-based investigations:**

- “Enabling activities”, which cover Major Products that may be required to support applications for intrusive surface-based investigations.
- “Investigation activities”, which includes preparation of the Major Products that may be required to support a Government decision on a preferred site.

Figure 5 illustrates the terminology used to describe the timing for production of Major Products in the S&T Programme. This figure also illustrates the maintenance of parallel generic and site-specific work streams across RWM’s S&T work programme over significant periods of time (as discussed in Section 2.4) and the gradual transition towards a purely site-specific programme.

## S&T Programme – Structure

**Figure 5** Phases in the development of a GDF and link to terminology used in the S&T Programme to describe the timing for the production of Major Products



## S&T Programme – Delivery

---

### 3 Delivery of RWM's S&T Programme

#### 3.1 Role of Major Products

RWM defines Major Products as:

*High level deliverables aimed at meeting the requirements of relevant legislation or the expectations of Government, regulators, or other major stakeholders. As such they are likely to reflect a substantial commitment within the work programme, and have wide circulation amongst key stakeholders.*

Major Products are the outputs from packages of technical work which RWM will use to demonstrate progress in achieving its mission. Major Products are not always a single, written deliverable. Other types include:

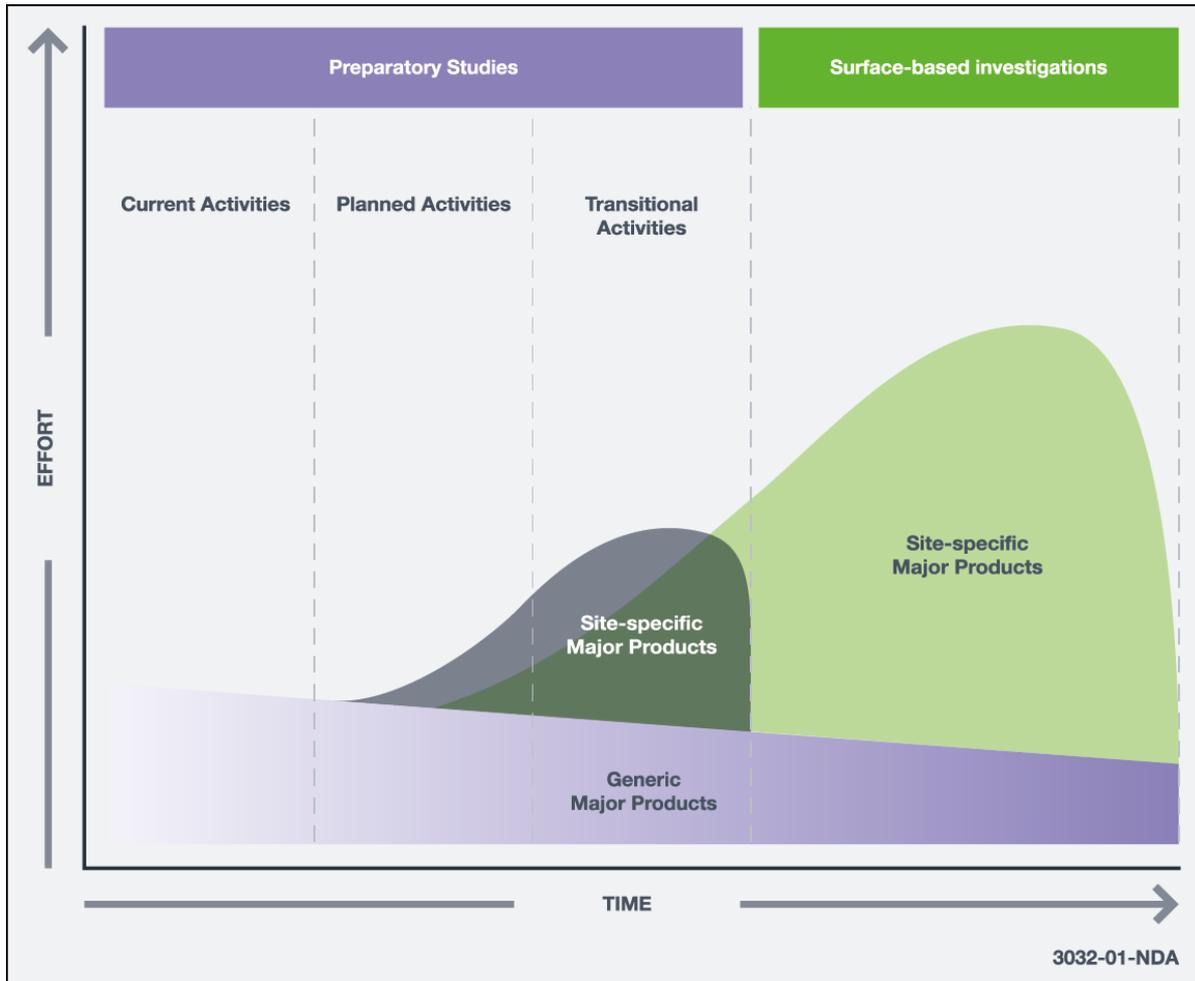
- Suites of documents, such as disposability assessments, Letters of Compliance (LoC) and waste package specifications (Major Products AS13, AS14 and AS15 respectively), as discussed in Section 6.
- Databases or models, such as the Management System for Geoscientific Data (Major Product KB21), described in Section 7.

Some Major Products have already been produced, and will be maintained and/or updated going forward, whereas others are part of RWM's future work programme. Some Major Products are required for a particular stage of the RWM work programme. Work on these Major Products will ramp-up over the course of the relevant phase of activities, as illustrated in Figure 6.

The descriptions later in this document identify the current status of each Major Product. The list of Major Products is subject to update as RWM's programme progresses.

## S&T Programme – Delivery

Figure 6 S&T Programme – indicative profile of work



### 3.2 Structured summary of Major Products in each work area

Sections 4 to 7 of the S&T Programme provide descriptions of Major Products under each of the four overarching work areas associated with RWM's iterative development process (Disposal System Specification, Disposal System Design, Assessments and Underpinning Knowledge Base work areas, respectively).

To aid navigation through this document the relevant overarching work area is identified in the headers for Sections 4 to 7. In addition, each of the overarching work areas has been assigned a different colour: **bottle green** for Disposal System Specification, **olive green** for Disposal System Design), **orange** for Assessments and **yellow** for Underpinning Knowledge Base. Colour-coded sidebars are used throughout Sections 4 to 7 to further aid the reader.

At the start of each section, the following figures are provided:

- A product breakdown diagram summarising the hierarchy of work areas and associated Major Products. An example of such diagrams is provided in Figure 7. Major Products are shown in white boxes under the relevant work area.
- An indicative schedule for delivery of the Major Products within the work area in question, based on the phases of activity described in Section 2.5. An example indicative schedule is provided in Figure 8. These schematics list generic and site-specific Major Products separately.

## S&T Programme – Delivery

---

Five labels are used within the indicative schedules to describe how and when Major Products will be prepared and delivered:

- “Develop” (green oval) is used to indicate when work first starts on a Major Product and the period during which work on the Major Product is in progress.
- “Publish” (blue oval) indicates that work on the first version of a Major Product will be completed during this phase, and that it will be approved for issue (and in most cases, publication).
- Major Products that have already been published are indicated by a dark blue “Published” oval.
- “Maintain” (black labelled arrow) is used to indicate when minor updates or addendums may be made to a document, after its initial issue. This label is typically applied to ‘living’ documents, which are continually edited and updated to reflect developments as RWM’s programme progresses.
- “Update” (purple oval) is used for documents where it is appropriate to undertake a significant, focused revision and reissue of the document, usually associated with some specific regulatory requirement, progression through GDF siting, or a notable milestone in RWM’s programme. For example, it is envisaged that the existing GDF Implementation Plan (Major Product DE12) will be significantly updated once potential sites have been identified, to describe RWM activities associated with surface-based investigations of these sites.

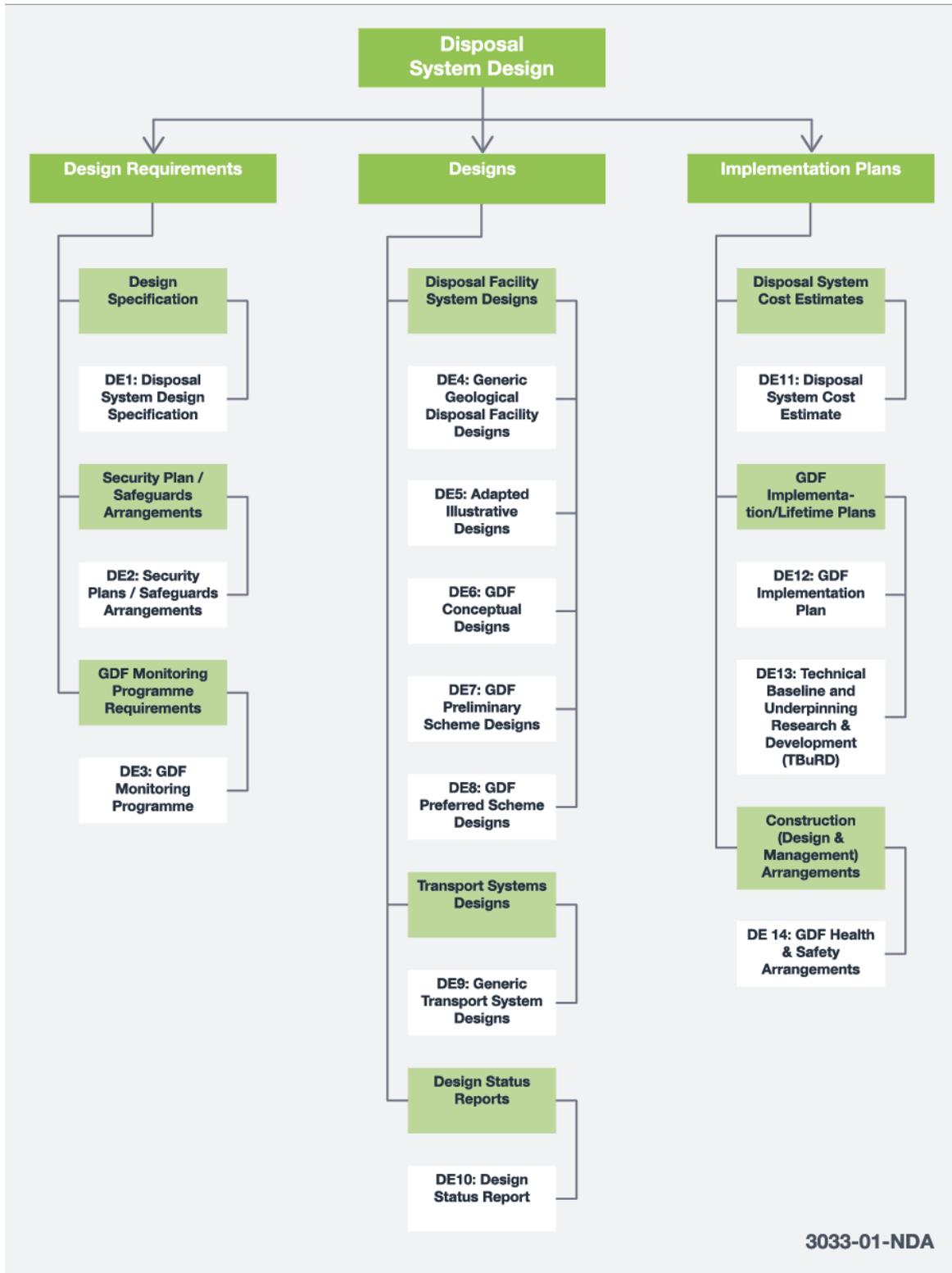
Documents that are not maintained or updated after they are first issued, such as the GDF Conceptual Designs (Major Product DE6), are typically produced to meet a specific requirement at a fixed point in time. After this requirement has been met, they are retained for future reference. They may still be used as an input to inform development of a subsequent Major Product; however they will not be revised or reissued.

## S&T Programme – Delivery

Figure 7 Example product breakdown diagram

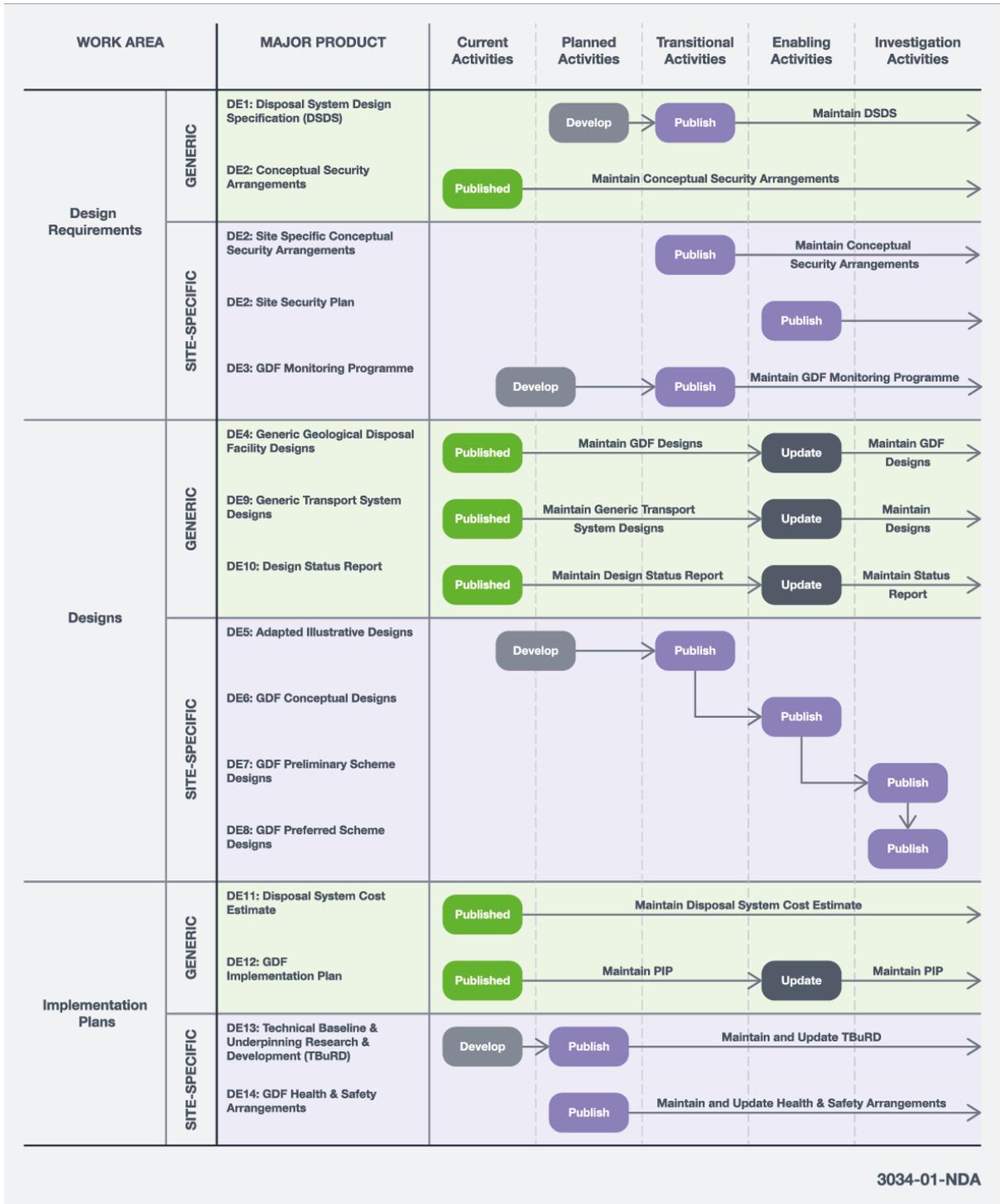
(In this case, illustrating the hierarchy of work areas and associated Major Products within the disposal system design work area)

Each Major Product is shown in a white box



# S&T Programme – Delivery

**Figure 8 Example indicative schedule showing the timescales for production of Major Products in the disposal system design work area**



## S&T Programme – Delivery

---

### 3.3 Structure of Major Product descriptions

Introductory material at the start of Sections 4 to 7 is followed by a description of each of the Major Products identified. Major Product descriptions are typically one to two pages long, and include the following information, incorporated into a template with a standard layout for ease of reference / comparison:

- A sentence describing the **purpose** of the Major Product (purple text box).
- A short **overview** of the Major Product, setting out its scope, applicability and role within RWM's wider S&T Programme (blue text box). This provides context to subsequent, more detailed information, and also enables the reader to gain a high-level understanding of the deliverable in question without reading further.
- An explanation of the **information needs** (knowledge gaps) **and strategic objectives** addressed by the Major Product.
- Identification of the relevant **drivers** applicable to the Major Product, focusing in particular on external legislative and regulatory drivers and other commitments to stakeholders. Drivers are indicated in a series of tick boxes – any additional clarification required is recorded in a separate **notes** field.
- A high-level description of **current work requirements** associated with the Major Product, i.e. work that is planned within the next decade. This may describe the process for development of the Major Product itself, or it may outline tasks associated with the Major Product.
- A high-level description of **longer term work requirements** associated with the Major Product, i.e. work that is planned more than ten years in the future. Such work is often site-specific in nature.
- A list of **references** cited in the Major Product description. Including references at the end of each description, rather than at the end of the S&T Programme, means that individual Major Product descriptions are self-contained and can therefore be removed from the S&T Programme and used as stand-alone documents.

In several instances, a single, combined description of several related Major Products is provided, rather than separate descriptions of each Major Product, in order to avoid repetition. This approach is commonly applied where both generic and site-specific versions of a Major Product are planned, for example, to describe the research status reports in Section 7. In such cases, the current work requirements section sets out generic research planned in the next few years, whereas the section on longer term requirements describes research that will feed into site-specific versions of the status report. However, this approach is not always followed. For example the generic and site-specific safety cases discussed in Section 6 are described separately, to avoid confusion.

Within the descriptions of relevant Major Products the reader should be able to identify appropriate high-level discussion of issues identified within RWM's Issues Register [7], and to understand broadly how each issue is being addressed. More extensive discussion of many issues can be found in the S&T Plan [4].

### 3.4 Summary of Major Products

Figure 9 summarises the Major Products that have been, or will be, delivered through RWM's S&T Programme, as well as the descriptions provided within this document. As described in Section 2.2, each Major Product has been assigned a unique number under one of RWM's four main S&T work areas, which can be used to look up the relevant description later in the report.

## S&T Programme – Delivery

**Figure 9 Summary of RWM's Major Products and the associated descriptions provided in the S&T Programme**  
(continued on next page)

Main (Level 1) Work Area	Level 2 Work Area	MP Number	Major Product Name	Description in the S&T Programme	
Disposal System Specification (Section 4)	Specification	SP1	Disposal System Functional Specification	Disposal System Specifications (single combined description)	
		SP2	Generic Disposal System Technical Specification		
		SP3	Site-specific Disposal System Specification(s)		
	Inventory	SP4	Derived Inventory Reports	Derived Inventory Reports	
	Concepts	SP5	Concepts Status Report	Concepts Status Report	
	Alternatives	SP6	Alternatives: Review of Options	Alternatives: Review of Options	
Disposal System Design (Section 5)	Design Requirements	DE1	Disposal System Design Specification	Disposal System Design Specification	
		DE2	Security Plans / Safeguard Arrangements	Security Plans / Safeguard Arrangements	
		DE3	GDF Monitoring Programme	GDF Monitoring Programme	
	Designs	DE4	Generic Geological Disposal Facility Designs	Geological Disposal Facility Designs (single combined description)	
		DE5	Adapted Illustrative Designs		
		DE6	GDF Conceptual Designs		
		DE7	GDF Preliminary Scheme Designs		
		DE8	GDF Preferred Scheme Designs		
		DE9	Generic Transport System Designs		Generic Transport System Designs
		DE10	Design Status Report		Design Status Report
	Implementation Plans	DE11	Disposal System Cost Estimate	Disposal System Cost Estimate	
		DE12	GDF Implementation Plan	GDF Implementation Plan	
		DE13	Technical Baseline and Underpinning Research and Development (TBuRD)	Technical Baseline and Underpinning Research and Development (TBuRD)	
		DE14	GDF Health and Safety Arrangements	GDF Health and Safety Arrangements	
Assessments (Section 6)	Safety Assessment	AS1	Generic Disposal System Safety Case	Generic Disposal System Safety Case	
		AS2	Generic Transport Safety Case	Generic Transport Safety Case	
		AS3	Generic Operational Safety Case	Generic Operational Safety Case	
		AS4	Generic Environmental Safety Case	Generic Environmental Safety Case	
		AS5	Site-specific Disposal System Safety Cases	Site-specific Disposal System Safety Cases	
		AS6	Preliminary Transport Safety Report	Preliminary Transport Safety Report	
		AS7	Preliminary (Operational) Safety Report	Preliminary (Operational) Safety Report	
		AS8	Initial Environmental Safety Case	Initial Environmental Safety Case	

## S&T Programme – Delivery

	Environmental and Socio-economic Assessment	AS9	Generic Environmental Assessment	Generic Environmental Assessment
		AS10	Generic Socio-economic Assessment	Generic Socio-economic Assessment
		AS11	Generic Health Impact Assessment	Generic Health Impact Assessment
		AS12	Community-specific Environmental Assessments	Community-specific Environmental Assessments
	Waste Packaging Assessment	AS13	Disposability Assessments	Disposability Assessments
		AS14	Letters of Compliance	Letters of Compliance
		AS15	Generic Waste Package Specifications and Guidance Documentation	Generic Waste Package Specifications and Guidance Documentation
	GDF Siting	AS16	National Geological Screening Reports	National Geological Screening Reports
		AS17	Site Selection Framework	Site Selection Framework
		AS18	Development Consent Application for Boreholes	Development Consent Application for Boreholes
		AS19	Property Value Protection Approach	Property Value Protection Approach
		AS20	Approach to Acquisition of Land and Mineral Rights	Approach to Acquisition of Land and Mineral Rights
Underpinning Knowledge Base (Section 7)	HAW Programme	KB1	Higher Activity Waste (HAW) Programme	Higher Activity Waste (HAW) Programme
	Research and Development	KB2	Science and Technology (S&T) Plan	Science and Technology (S&T) Plan
		KB3	Generic Package Evolution Status Report	Package Evolution Status Reports (single combined description)
		KB4	Site-specific Package Evolution Status Report	
		KB5	Generic Engineered Barrier System Status Report	Engineered Barrier System Status Reports (single combined description)
		KB6	Site-specific Engineered Barrier System (EBS) Status Report	
		KB7	Generic Geosphere Status Report	Geosphere Status Reports (single combined description)
		KB8	Site-specific Geosphere Status Report	
		KB9	Generic Biosphere Status Report	Biosphere Status Reports (single combined description)
		KB10	Site-specific Biosphere Status Report	
		KB11	Generic Gas Status Report	Gas Status Reports (single combined description)
		KB12	Site-specific Gas Status Report	
		KB13	Generic Radionuclide Behaviour Status Report	Radionuclide Behaviour Status Reports (single combined description)
		KB14	Site-specific Radionuclide Behaviour Status Report	
		KB15	Generic Waste Accident Performance Status Report	Waste Package Accident Performance Status Report
		KB16	Generic Criticality Safety Status Report	Criticality Safety Status Reports (single combined description)
		KB17	Site-specific Criticality Safety Status Report	
		Site Characterisation	KB18	Site Characterisation Status Report
	KB19		Development of a Conceptual Understanding of the Geosphere	Developing a Conceptual Understanding of the Geosphere
	KB20		Site Characterisation Programme	Site Characterisation Programme
	KB21		Management System for Geoscientific Data	Management System for Geoscientific Data
	KB22		Initial Site Evaluations	Initial Site Evaluations

3035-01-NDA

## S&T Programme – Delivery

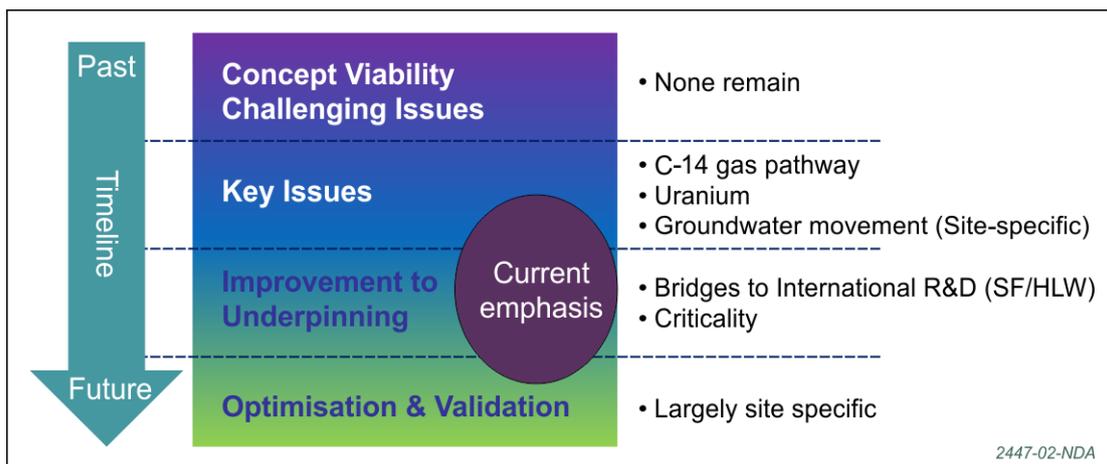
### 3.5 Current status of RWM’s S&T programme

Having undertaken three decades of research into the geological disposal of UK wastes, significant progress has been made in the fundamental understanding of features, events and processes impacting on the safety functions of a GDF. Figure 10 is a representation of the evolution of the knowledge base underpinning geological disposal. It shows how the emphasis of a prioritised research programme evolves. At this time, challenges to the viability of geological disposal have been overcome and current work focuses on addressing key uncertainties and improving the understanding that underpins geological disposal. Once a potential site has been identified, the emphasis of RWM’s S&T Programme will move towards the selection of a suitable disposal concept for application at that site combined with work to optimise the specification, design and associated safety assessments for the site-specific conditions, and validation of the basis for safety provided by the disposal system.

Over the last few years, key issues that are relevant across RWM’s S&T Programme (for example, the behaviour of carbon-14, the influence of heat generated from certain radioactive wastes and materials on engineered barrier systems, and the long-term impact of disposing of large quantities of depleted, natural and low enriched uranium) have been explored through a series of projects. Other key issues, such as the behaviour of groundwater, are inherently site specific and cannot be studied in detail during the generic phase of RWM’s activities. To address the need for improvements in understanding, a considerable body of work is underway, focusing on key areas of uncertainty, for example the likelihood and consequences of criticality.

RWM’s work programme draws on international research and development wherever possible, as a cost effective way of addressing knowledge gaps and building confidence in its programme. RWM aims to evaluate the extent to which such work is applicable to the UK inventory, e.g. work carried out overseas on spent fuel post-closure evolution and the durability of vitrified HLW.

**Figure 10** Timeline for the evolution of RWM’s knowledge base, with examples of current research priorities



## S&T Programme – Specification Major Products

### 4 Major Products in the disposal system specification (DSS) work area

The aim of the DSS is to set out a clear definition of what is required of the disposal system. It forms an important input to the development of cost-effective engineering designs and enables their fitness for purpose to be evaluated. It includes regulatory constraints and stakeholder requirements, and takes account of the nature and quantities of the wastes.

The DSS comprises two documents:

- The Disposal System Functional Specification (DSFS): The primary purpose of the DSFS is to identify and document the high-level requirements on the disposal system for endorsement by the RWM Board. The DSFS is also aimed at communicating the high-level requirements on the disposal system to a wide range of stakeholders.
- The Disposal System Technical Specification (DSTS): This underpins the DSFS and develops a high level specification by describing in more detail the requirements and constraints on the disposal system, together with a justification for each requirement. The DSTS defines the scope and bounds of the engineering design work. Its primary objective is to provide the designers of the disposal system (i.e. RWM's Engineering function) with the requirements that must be satisfied. It is written for a technical audience and published to enable review and scrutiny of RWM's work programme (e.g. by regulators and other technical experts).

The DSTS is currently generic, but site-specific versions will be developed in the future. Requirements in the DSFS and DSTS are presented as a series of "shall statements", which identify the requirements that the disposal system must meet (shown in **red italicised bold text**). Where an assumption has been made regarding a particular requirement for planning purposes, the assumption is shown underneath the requirement it relates to (shown in **purple italicised text**). Each "shall statement" and assumption where relevant is supported by further information providing the background and the justification for including it within the DSTS. An example excerpt from the DSTS is provided in Figure 11.

Specification

Design

Assessment

Underpinning Knowledge Base

## S&T Programme – Specification Major Products

**Figure 11 Excerpt from the DSTS illustrating the approach to specify and justify requirements on the disposal system**

**This example relates to security and physical protection**

<p><b>The disposal system shall be designed to provide physical protection and security measures to prevent misuse of fissile or radioactive materials to meet the requirements of the competent authority (i.e. Office of Civil Nuclear Security) under the Nuclear Industries Security Regulations.</b></p>	<p>Physical protection and security measures are required for the safety of the public and staff, protection of plant and equipment, and the safeguarding of nuclear materials. The Nuclear Industry Security Regulations 2003 [1] require certain premises on which nuclear material and/or other radioactive material are present to have a nuclear site security plan that describes in writing the standards, procedures and arrangements adopted or to be adopted by the operator to ensure the security of the premises. This includes the nuclear material and/or other radioactive material, any equipment or software associated with its management and any sensitive nuclear information. A security plan would be prepared and submitted to the ONR's Civil Nuclear Security (CNS) programme for approval.</p>
<p><b>It is assumed that a geological disposal facility for LLW, ILW, HLW and spent fuel will be a Category II facility as a minimum under the current system. The inclusion of plutonium and high-enriched uranium (HEU) waste may require re-categorisation as a Category I facility.</b></p>	<p>RWM will consult with ONR during the design of the disposal system, and any undertaking to design a Category I or Category II facility will necessitate the allocation of an ONR Inspector to oversee and approve the security measures.</p>

3037-01-NDA

Specification

Design

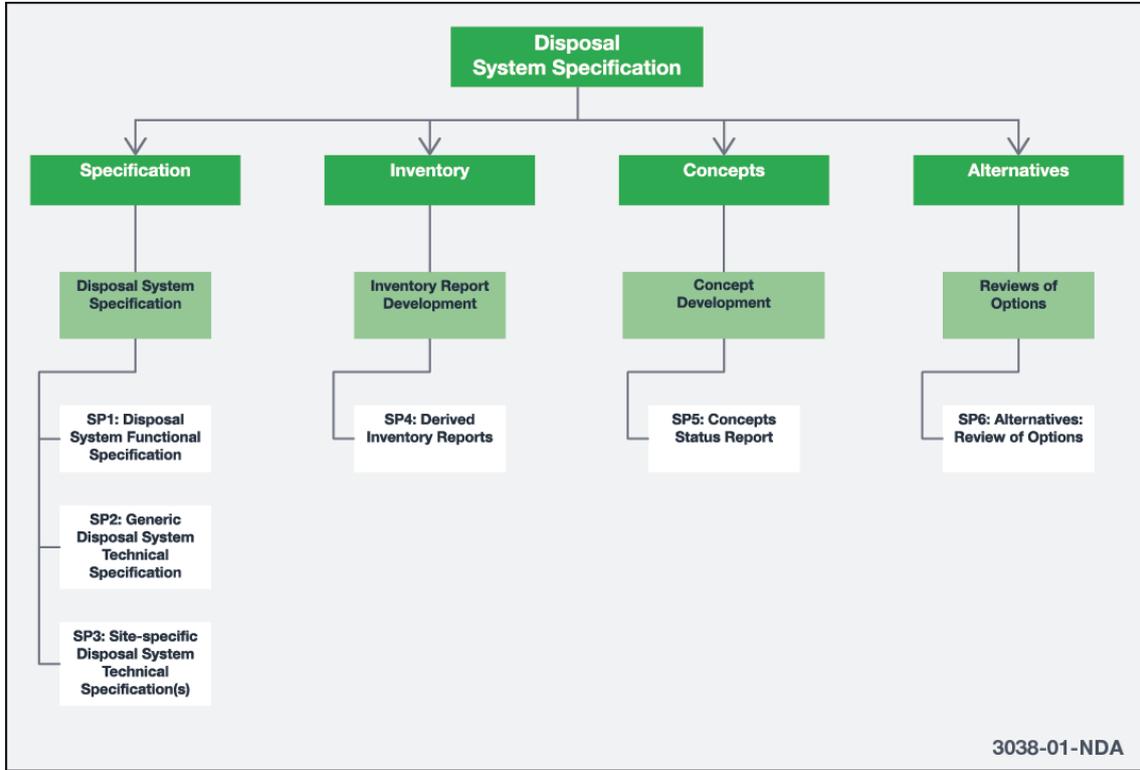
Assessment

Underpinning Knowledge Base

# S&T Programme – Specification Major Products

The DSS work area has six Major Products associated with it, as shown in Figure 12. The indicative schedule for producing these Major Products is shown in Figure 13.

**Figure 12 Product breakdown structure for the DSS work area**  
Major Products are shown in white boxes



**Figure 13 Indicative schedule for the production of Major Products in the DSS work area**

WORK AREA	MAJOR PRODUCT	Current Activities	Planned Activities	Transitional Activities	Enabling Activities	Investigation Activities
Specification	GENERIC SP1: Disposal System Functional Specification	Published				Maintain Specification
	GENERIC SP2: Generic Disposal System Technical Specification	Published	Maintain Specification		Update	Maintain Specification
	SITE-SPECIFIC SP3: Site-specific Disposal System Technical Specification(s)			Develop	Publish	Maintain Specification
Inventory	GENERIC SP4: Derived Inventory Reports	Published	Maintain DI	Update	Maintain DI	Update
Concepts	GENERIC SP5: Concepts Status Report	Published				Maintain Concepts
Alternatives	GENERIC SP6: Alternatives: Review of Options	Published				Maintain Alternative Waste Management Options

3039-01-NDA

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Specification Major Products

## Disposal System Specifications (Major Products SP1, SP2 & SP3)

### Purpose

To identify and control all disposal system requirements under RWM’s iterative development process.

### Information needs and strategic objectives

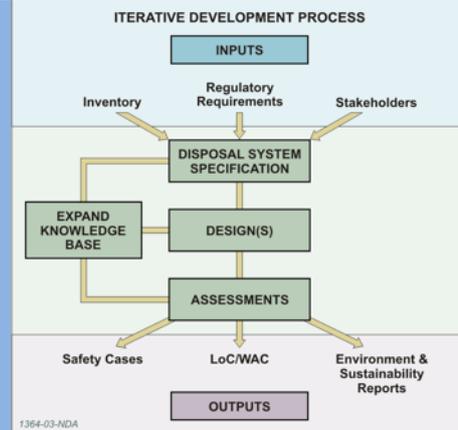
The DSFS and the DSTS support RWM’s strategic objective to “Develop the specification, design, safety case and environmental sustainability assessments for the disposal system and obtain regulatory support”.

The information needs addressed by the DSFS and DSTS may be considered in two ways:

- (1) The DSS sets out the current understanding of the requirements on the disposal system. These requirements cover the following sub-systems: waste packaging and conditioning, transport and geological disposal. Requirements affect the activities required to design, implement and operate each of these sub-systems.
- (2) The development of the DSS and design is an iterative process, with complementary assessments of safety, environmental impact and cost; these assessments are iteratively used to identify where R&D is needed.

The DSS forms part of a suite of documents that describe the technical baseline for the disposal system in the UK (i.e. the knowledge platform of science, technology and engineering). The document suite is aligned to the generic phase of the programme and this will be expected to develop significantly as the programme moves into the site-specific phase. The technical baseline will be crucial in supporting key decisions as the programme progresses.

In order to deliver its mission, RWM needs to ensure that the GDF is suitable for the UK’s higher activity radioactive waste. In support of this requirement, developments and changes to the disposal system are managed by a change control procedure. This is done in a way that ensures that the suite of documents setting out the technical baseline continues to form a robust and consistent basis for both internal and external users, including supporting key decisions.



RWM’s iterative development process

### Overview

The aim of the DSS is to set out what is required of the disposal system. It forms an important input to the development of cost-effective engineering designs and enables their fitness for purpose to be evaluated. It includes regulatory constraints and stakeholder requirements, and takes account of the nature and quantities of the wastes.

The DSS comprises two documents:

- The Disposal System Functional Specification (DSFS), which identifies high-level requirements on the disposal system.
- The Disposal System Technical Specification (DSTS), which underpins the DSFS by describing in more detail the requirements and constraints on the disposal system, together with their justification. The DSTS is currently generic but site-specific versions will be developed in future.

### Drivers

Commercial / Contractual		Cost Impacts		Design Codes & Standards	✓
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	
NDA Strategy		Operational Safety Case	✓	Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning		Site Characterisation Results	✓	Siting Process (Voluntarism)	✓
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	✓
Waste Package Disposability	✓				

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Specification Major Products

Specification	<p><b>Current Work Requirements</b></p> <p>The generic DSTS will be maintained during RWM’s preparatory studies and surface-based investigations phases, to provide a basis for generic designs, safety and environmental assessments and to underpin packaging advice. Upcoming tasks to inform the DSTS are summarised below.</p> <p><b>(a) Integration of the DSS into a Requirements Management System (RMS)</b></p> <p>In order to clearly communicate the requirements on the disposal system in a format that can be easily addressed by other RWM functions, and in line with international best practice, RWM is exploring integrating the DSS with a RMS to support the site-specific stage of its programme. This will also clarify the relationships between the DSS and other RWM specifications, such as the Disposal System Design Specification (Major Product DE1) and the Generic Waste Package Specification (Major Product AS15). The RMS, when fully developed, will:</p> <ul style="list-style-type: none"> <li>➤ Allow each element of the design to be traced back to its driving requirements.</li> <li>➤ Demonstrate traceably that the design solutions as a whole meet the requirements of the DSS.</li> <li>➤ Identify requirements that are specific to different host rock environments and are applicable to testing a range of concepts for that environment, in order to support the development of a site-specific DSTS.</li> </ul> <p><b>(b) Temperature Limits on Engineered Barrier Materials</b></p> <p>The generic DSTS specifies temperature limits on engineered barriers following closure to be assumed at the generic stage. These limits will depend on the safety function(s) that each barrier will be required to perform in a particular geological environment. Since RWM does not yet know the geological environment for which it will need to design a geological disposal concept, the currently assumed requirements are based on illustrative concepts. Work is being undertaken to better understand the impact of elevated temperatures on the performance of engineered barrier materials in support of concept development and specification of requirements at the site-specific stage.</p> <p><b>(c) Disposal of Vitrified ILW</b></p> <p>The generic DSTS currently conservatively assumes that vitrified ILW requires a separate vault to other ILW to ensure that all disposal modules will function as intended without interactions occurring between different systems that unacceptably affect their performance. Work is being undertaken to further develop the understanding of vitrified ILW behaviour under GDF conditions and whether a separate vault will be required. This work includes investigating:</p> <ul style="list-style-type: none"> <li>➤ The impact of vitrified ILW on cement backfill performance, including low pH cements.</li> <li>➤ Dissolution of vitrified ILW under GDF conditions to develop a mechanistic understanding of its evolution.</li> </ul> <p><b>(d) Disposal of Robust Shielded Containers (RSCs)</b></p> <p>The generic DSTS currently assumes that ductile cast iron containers will be placed in separate ILW vaults with a backfill ratio of 1:1. Work is being undertaken to further develop RWM’s understanding of the impact of these new waste package types on cement backfill performance and to inform the specification of appropriate backfill ratios.</p>
Design	
Assessment	
Underpinning Knowledge Base	<p><b>Longer Term Work Requirements</b></p> <ul style="list-style-type: none"> <li>➤ Site-specific DSTS documents will be developed in parallel with maintenance of the generic DSTS to support the selection of illustrative concepts for each candidate site as follows: <ul style="list-style-type: none"> <li>- The generic DSTS will be used as the starting point for a site-specific DSTS. The site-specific DSTS will progressively develop to include more detailed site-specific requirements and replace assumptions. Requirements will be refined in light of the results from design development, assessments and R&amp;D.</li> <li>- The iterative process, and development of a site-specific DSTS, will allow identification of requirements which may be interpreted differently in specific geological environments.</li> </ul> </li> <li>➤ The DSFS will be maintained as an overarching document defining requirements at the highest level.</li> <li>➤ A site-specific DSTS will provide a basis for site-specific designs, safety and environmental assessments and ultimately waste acceptance criteria (WAC).</li> </ul>

# S&T Programme – Specification Major Products

## Derived Inventory Reports (Major Product SP4)

<p><b>Purpose</b></p> <p>To identify the likely nature and quantities of waste requiring geological disposal, and hence to support design and safety case development.</p>																																																			
<p><b>Information needs and strategic objectives</b></p> <p>The quantity and characteristics of the waste and nuclear materials that may ultimately be designated as radioactive waste, together with their associated packaging arrangements fundamentally control the scale and nature of any disposal system design. The UKRWI contains an extensive amount of data, which require some modification or enhancement before they can be used in RWM’s design and safety assessments. For example, the 2013 UKRWI does not give any information on the chemical compositions, radionuclide activities and packaging for spent fuel or separated stocks of uranium and plutonium. Also, the information provided in the 2013 UKRWI relates to waste streams, but in order to develop safety cases data are required at the waste package level (see also the “Notes” section).</p> <p>A Derived Inventory has therefore been developed from the UKRWI to provide a dataset focused on the provision of data for waste packages rather than waste streams. The Derived Inventory has been prepared through a review of NDA’s requirements, an analysis of the UKRWI data and other data sources including previous inventories and LoC submissions. A methodology for enhancing the data has been established, and an audit trail maintained that gives the source of, and justification for, all data modifications. Enhancements have focused on a number of materials and radionuclides identified as priorities for RWM’s work.</p> <p>The Derived Inventory is developed from the UKRWI plus foreseeable nuclear industry developments as advised by key stakeholders such as DECC and the NDA. It also takes account of packaging development work conducted by RWM. A new version is produced each time the UKRWI is updated (approximately every three years). The latest version is aligned with the 2013 UKRWI [1].</p>		<p><i><b>ILW packaged in specially-designed stainless steel drums</b></i></p> <p><b>Overview</b></p> <p>The Derived Inventory contains detailed descriptions of the wastes and radioactive materials that may ultimately become wastes, which may require disposal in a GDF. It draws heavily on the latest United Kingdom Radioactive Waste Inventory (UKRWI) and studies by RWM and waste producers on appropriate waste packaging methodologies.</p> <p>Work in this area includes maintaining the DIQuest database tool used to store inventory data and performing calculations to model radioactive decay, heat output and dose rates associated with packaged waste.</p>																																																	
<p><b>Drivers</b></p> <table border="1"> <tr> <td>Commercial / Contractual</td> <td></td> <td>Cost Impacts</td> <td>✓</td> <td>Design Codes &amp; Standards</td> <td></td> </tr> <tr> <td>Disposal Concept Development</td> <td>✓</td> <td>Disposal System Design</td> <td>✓</td> <td>Disposal System Specification</td> <td>✓</td> </tr> <tr> <td>Environmental Impact &amp; Sustainability</td> <td></td> <td>Environmental Safety Case</td> <td>✓</td> <td>Flexibility in Decision Making</td> <td></td> </tr> <tr> <td>NDA Strategy</td> <td>✓</td> <td>Operational Safety Case</td> <td>✓</td> <td>Programme / Risk Management</td> <td></td> </tr> <tr> <td>QA / Data Robustness</td> <td></td> <td>Regulatory Requirements</td> <td>✓</td> <td>Safety Case Methodology</td> <td></td> </tr> <tr> <td>Site Assessment / Permissioning</td> <td></td> <td>Site Characterisation Results</td> <td></td> <td>Siting Process (Voluntarism)</td> <td>✓</td> </tr> <tr> <td>Socioeconomic Impacts</td> <td></td> <td>Stakeholder Engagement</td> <td>✓</td> <td>Transport Safety Case</td> <td>✓</td> </tr> <tr> <td>Waste Package Disposability</td> <td>✓</td> <td></td> <td></td> <td></td> <td></td> </tr> </table>				Commercial / Contractual		Cost Impacts	✓	Design Codes & Standards		Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓	Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making		NDA Strategy	✓	Operational Safety Case	✓	Programme / Risk Management		QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology		Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)	✓	Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	✓	Waste Package Disposability	✓				
Commercial / Contractual		Cost Impacts	✓	Design Codes & Standards																																															
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓																																														
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making																																															
NDA Strategy	✓	Operational Safety Case	✓	Programme / Risk Management																																															
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology																																															
Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)	✓																																														
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	✓																																														
Waste Package Disposability	✓																																																		
<p><b>Notes:</b> Other examples of where the data provided in the UKRWI are incomplete, or are not presented in a format that can be used by RWM, include the following:</p> <ul style="list-style-type: none"> <li>➤ Waste packages are not always identified and for unshielded packages the transport container is not defined.</li> </ul>																																																			

Specification

Design

Assessment

Underpinning Knowledge Base

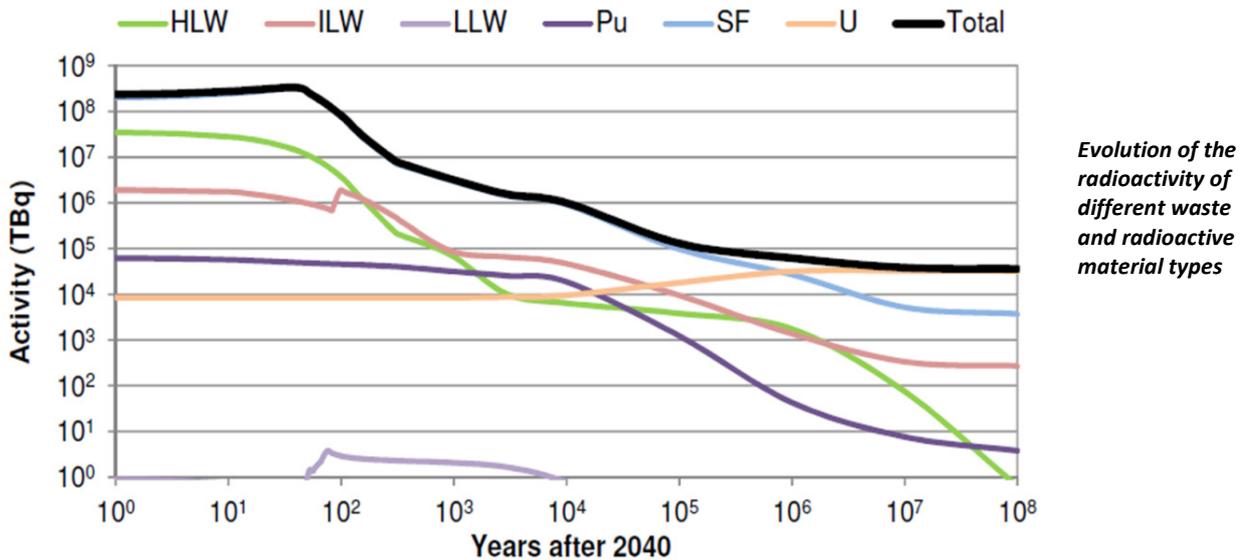
# S&T Programme – Specification Major Products

Specification

- Data providers often use “less than” prefixes with material component values that can result in significant overestimates when these values are summed.
- Robust inventory determination methods are not always used and in some cases data are qualitative only.

## Current Work Requirements

With each successive update to the UKRWI there is a need to, as a minimum, examine the implications for the Derived Inventory of such updates. Collation of the inventory provides a key input to the Disposal System Safety Case; the Figure below illustrates the effect of radioactive decay on the inventory over long timescales.



Design

To provide convenient access to the Derived Inventory and provide a vehicle for executing certain related physics calculations, such as decay, heat output and dose-rate calculations, the Derived Inventory Query and Scenario Tool (DIQuest) has been developed. This database tool is used to support the development of waste nature and quantity datasheets for disposability assessments, as well as Derived Inventory work, and so its continued support and further development is an important component of this Major Product. Understanding the uncertainties present within the Derived Inventory and improving the justification for the data within it are also important activities.

Assessment

Work to maintain and develop the Derived Inventory includes DIQuest support and development activities, development of an improved understanding of inventory uncertainties, justification of the set of relevant radionuclides for all waste and radioactive material categories, improvements to the methodology for production of the Derived Inventory, and ongoing development of the methodology for feedback from the disposability assessment process to the UKRWI and Derived Inventory.

## Longer Term Work Requirements

A new version of the Derived Inventory is produced each time the UKRWI is updated (i.e. approximately every three years). Each update will reflect ongoing acquisition of improved data and associated refinement of the inventory.

Underpinning Knowledge Base

## References

- [1] NDA and DECC, 2014. *Radioactive Wastes in the UK: A Summary of the 2013 Inventory*, URN 14D039, NDA/ST/STY (14) 0006, February 2014.

# S&T Programme – Specification Major Products

## Concepts Status Report (Major Product SP5)

### Purpose

To provide disposal concepts that form a planning basis and sufficient flexibility to accommodate the UK radioactive waste inventory in a range of prospective geological environments.

### Information needs and strategic objectives

The Concepts Status Report describes a series of illustrative geological disposal concepts to illustrate the range of options that might be suitable for implementation in a UK GDF, depending on the nature of the geological environment. These illustrative concepts take account of the range of options implemented or under consideration in other countries, which could be adapted and developed into a UK solution. This responds to the RWM strategic objective to:

*“Seek sustainable, innovative and cost effective solutions that have public support and are in the best interest of the UK”.*

Developing a Range of Geological Disposal Concepts supports the RWM strategic activity to:

*“Utilise the wealth of knowledge and experience on geological disposal concepts developed in the UK and abroad as a platform to maintain a range of geological disposal concept options that are suitable for UK higher activity radioactive wastes”.*

At this stage, no geological disposal concept has been ruled out. Maintaining and developing the range of geological disposal concept options will allow RWM to select and develop appropriate concepts for the UK wastes requiring disposal when the geological environment for a GDF is known.



**Waste canisters could be emplaced in a variety of ways, for example in horizontal tunnels, as illustrated in this mock-up**

### Overview

At the current generic phase of the GDF siting process the range of geological environments that could be available for hosting a GDF is wide and diverse and a range of potentially suitable geological disposal concepts is being examined.

Drawing from this range of options RWM has set out illustrative geological disposal concepts for a number of generic geological environments identified for the UK, including the associated variants on host rocks and overlying strata.

### Drivers

Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	
NDA Strategy	✓	Operational Safety Case	✓	Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts	✓	Stakeholder Engagement	✓	Transport Safety Case	✓
Waste Package Disposability	✓				

### Current Work Requirements

The main deliverable associated with this Major Product is the ‘Geological Disposal Concepts Status Report’; this will replace References [1] and [2] and is currently in preparation. It sets out, in generic terms, available disposal concept options that are ready for adaptation to a particular geological environment. The report describes the characteristics of different disposal concepts and discusses the integration of concepts for different waste types, as well as the suitability of disposal concepts for different geological environments. Other planned tasks cover the following:

#### (a) Further Development of Concept Options to Support the Siting Process

The following work is being undertaken as part of an RWM integrated project to support the site selection process:

Specification

Design

Assessment

Underpinning Knowledge Base

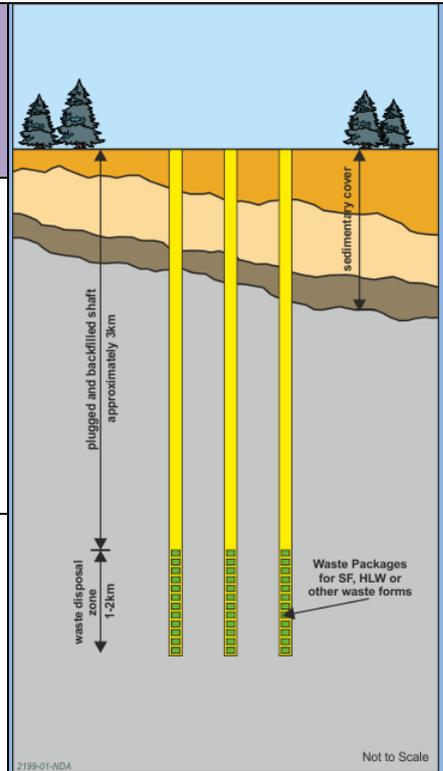
# S&T Programme – Specification Major Products

Specification	<ul style="list-style-type: none"> <li>➤ Providing more information on the benefits and constraints of less mature disposal concepts within the range of disposal concepts that could potentially offer flexibility. This includes: <ul style="list-style-type: none"> <li>- Vault Disposal. Such concepts have the potential to provide a smaller footprint; there is however a trade-off between the size of the footprint and the period before backfilling can take place, because denser packing of heat-generating waste means a longer delay to backfilling will be required to meet thermal constraints on engineered barriers. Studies are planned to develop a more defined concept and engineering design and an understanding of the safety performance, together with the identification of knowledge gaps.</li> <li>- Mined Borehole Matrix. In this type of concept, waste packages would be emplaced in stacks in long (~200 m or more) vertical boreholes which are bored from underground (rather than from the surface). This offers the advantage of utilising the vertical extent of a host rock. Although considered feasible in principle, the requirements on the engineered barriers for this type of concept have not been developed in detail and there are significant uncertainties requiring the emplacement of the buffer around the waste packages.</li> <li>- Super-container Concepts. Here, the waste, overpack or canister and buffer would be pre-assembled at a surface facility into a handling shell, usually made of steel, before axial emplacement in tunnels. This could result in a smaller excavated volume per waste package, thereby reducing cost and environmental impacts.</li> </ul> </li> <li>➤ Further developing the concept selection process, including developing an improved understanding of information and resource requirements and a populated knowledge base to support implementation.</li> </ul>
Design	<p>Work will be carried out to explore opportunities for, and identify issues associated with, more optimised combinations of disposal concepts for the broad range of UK higher activity wastes and materials.</p> <p>The sharing of surface facilities (access tunnels, construction support and security provision) for potentially incompatible disposal concepts could lead to significant benefits, including major cost savings and lower environmental impacts; this would require appropriate physical separation and design of the disposal areas. However, the alternative of there being more than one facility has not been ruled out, and the siting process in the UK is designed to be sufficiently flexible to accommodate this. Planned work on concept development includes consideration of concepts for specific waste types, as well as co-location and multi-horizon layouts.</p> <p><b>(b) Further Development of Concept Options to Support Packaging Advice</b></p> <p>Further information on geological disposal concepts is needed to support the provision of waste packaging and strategic advice by RWM, particularly for the following waste and material groups:</p> <ul style="list-style-type: none"> <li>➤ Plutonium residues (plutonium that is not suitable for re-use as mixed oxide fuel).</li> <li>➤ Depleted, natural and low-enriched uranium (DNLEU).</li> <li>➤ Exotic spent fuels.</li> <li>➤ Metallic spent fuels.</li> <li>➤ Highly-enriched uranium.</li> </ul> <p>Work is being undertaken as part of RWM’s integrated projects on concepts and uranium to develop concept descriptions to a sufficient level to understand the constraints and potential benefits that are applicable in each case.</p>
Assessment	<p><b>Longer Term Work Requirements</b></p> <p>Technology transfer is the term used to describe the commercial acquisition of a technology and implementation support from another party. There is significant potential for technology transfer from more advanced waste management programmes, subject to technical and commercial considerations.</p>
Underpinning Knowledge Base	<p><b>References</b></p> <p>[1] T.D. Baldwin, N.A. Chapman, and F.B. Neall, <i>Geological disposal options for high level waste and spent fuel</i>, GSL Report to NDA-RWMD, 2008.</p> <p>[2] T.W. Hicks, T.D. Baldwin, P.J. Hooker, P.J. Richardson, N.A. Chapman, I.G. McKinley, and F. B. Neall, <i>Concepts for the geological disposal of Intermediate-level radioactive waste</i>, GSL Report to NDA-RWMD, 0736-1, 2008.</p>

# S&T Programme – Specification Major Products

## Alternatives: Review of Options (Major Product SP6)

<p><b>Purpose</b></p> <p>To maintain a watching brief on national and international developments in alternative radioactive waste management options, including those that may influence the nature and quantity of waste requiring geological disposal.</p>
<p><b>Information needs and strategic objectives</b></p> <p>While Government policy is for the UK to pursue deep geological disposal RWM is required, as set out in the 2014 White Paper, to maintain an ongoing watching brief on alternative waste management options being researched nationally and internationally, which could have the potential to improve the long-term management of some of the UK’s higher activity radioactive wastes. The 2014 White Paper states that ongoing review of potentially appropriate solutions should include learning from and engaging with overseas programmes [1].</p>
<p><b>Current Work Requirements</b></p> <p>The scope of RWM’s review of alternative radioactive waste management options has been guided by the options short-listed by the Committee on Radioactive Waste Management (CoRWM) [2]:</p> <ul style="list-style-type: none"> <li>➤ Alternative management options, including long-term interim storage and waste treatment techniques such as partitioning and transmutation, which could reduce the nature and quantity of waste requiring disposal.</li> <li>➤ Alternatives to geological disposal for certain wastes, including near-surface disposal for short-lived waste, and deep borehole disposal.</li> </ul> <p>RWM is continuing to check for any developments in other potential waste management options (i.e. options not short-listed by CoRWM). However, these options (e.g. storage forever and disposal at sea or in outer space) are not expected to receive significant attention.</p> <p>Periodic reviews of alternative management options will inform the National Policy Statement / Environmental Impact Assessment processes. They will include identification and explanation of recent developments and explanation of their significance for the UK inventory, in particular:</p> <ul style="list-style-type: none"> <li>➤ Consideration of all potentially relevant factors (e.g. safety, technical feasibility, cost) and the rate at which the various developments are expected to advance as a result of ongoing R&amp;D.</li> <li>➤ Potential implications for implementation of geological disposal and for decommissioning and waste management within the NDA estate, in terms of programme, cost and risk, if a decision were taken to route some of the inventory towards one of the alternatives.</li> </ul>
<p><b>Longer Term Work Requirements</b></p> <p>During site investigations further information or site-specific details may lead to revisions in this review approach.</p>



*An illustration of an alternative disposal option, in this case using deep boreholes where the waste is emplaced several kilometres below the surface*

**Overview**

Although a decision has been made by the UK Government to manage higher activity radioactive waste through geological disposal, RWM is required to keep alternative management options under review and to consider any developments that could impact on the basis for selecting geological disposal as the long-term management method.

The findings will be published; this will provide the basis for communicating developments with Government and stakeholders.

Specification
Design
Assessment
Underpinning Knowledge Base

# S&T Programme – Specification Major Products

Specification

Drivers					
Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development	✓	Disposal System Design		Disposal System Specification	
Environmental Impact & Sustainability	✓	Environmental Safety Case		Flexibility in Decision Making	✓
NDA Strategy	✓	Operational Safety Case		Programme / Risk Management	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability					

**References**

[1] Department of Energy and Climate Change, *Implementing Geological Disposal: A Framework for the long-term management of higher activity radioactive waste*, URN 14D/235, July 2014.

[2] Committee on Radioactive Waste Management, *Managing our Radioactive Waste Safely: CoRWM’s recommendations to Government*, CoRWM Document 700, July 2006.

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

## 5 Major Products in the disposal system design work area

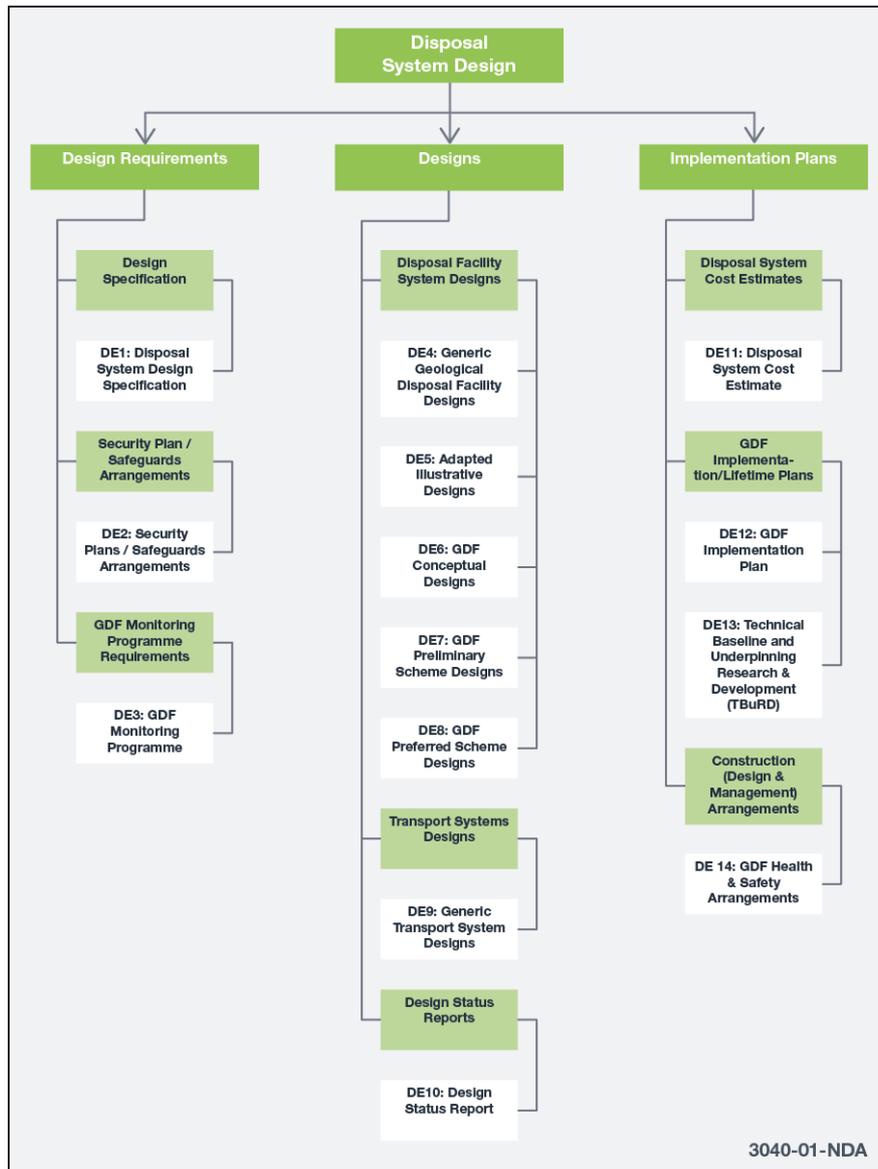
As the site selection process progresses, details of a geological environment, site-specific characteristics, and the preferred disposal system concepts will become available. Engineering designs will be developed that are tailored to the conditions of a potential site, based on appropriate geological disposal concepts. The detailed engineering designs will be prepared in a step-wise manner, commensurate with available information as the GDF implementation programme advances.

The disposal system design process has been broken down into a number of stages to reflect this and has 14 Major Products associated with it; these are illustrated in Figure 14.

The indicative schedule for producing these Major Products over the course of RWM’s work programme is shown in Figure 15.

**Figure 14 Product breakdown structure for the disposal system design work area**

Major Products are shown in white boxes



Specification

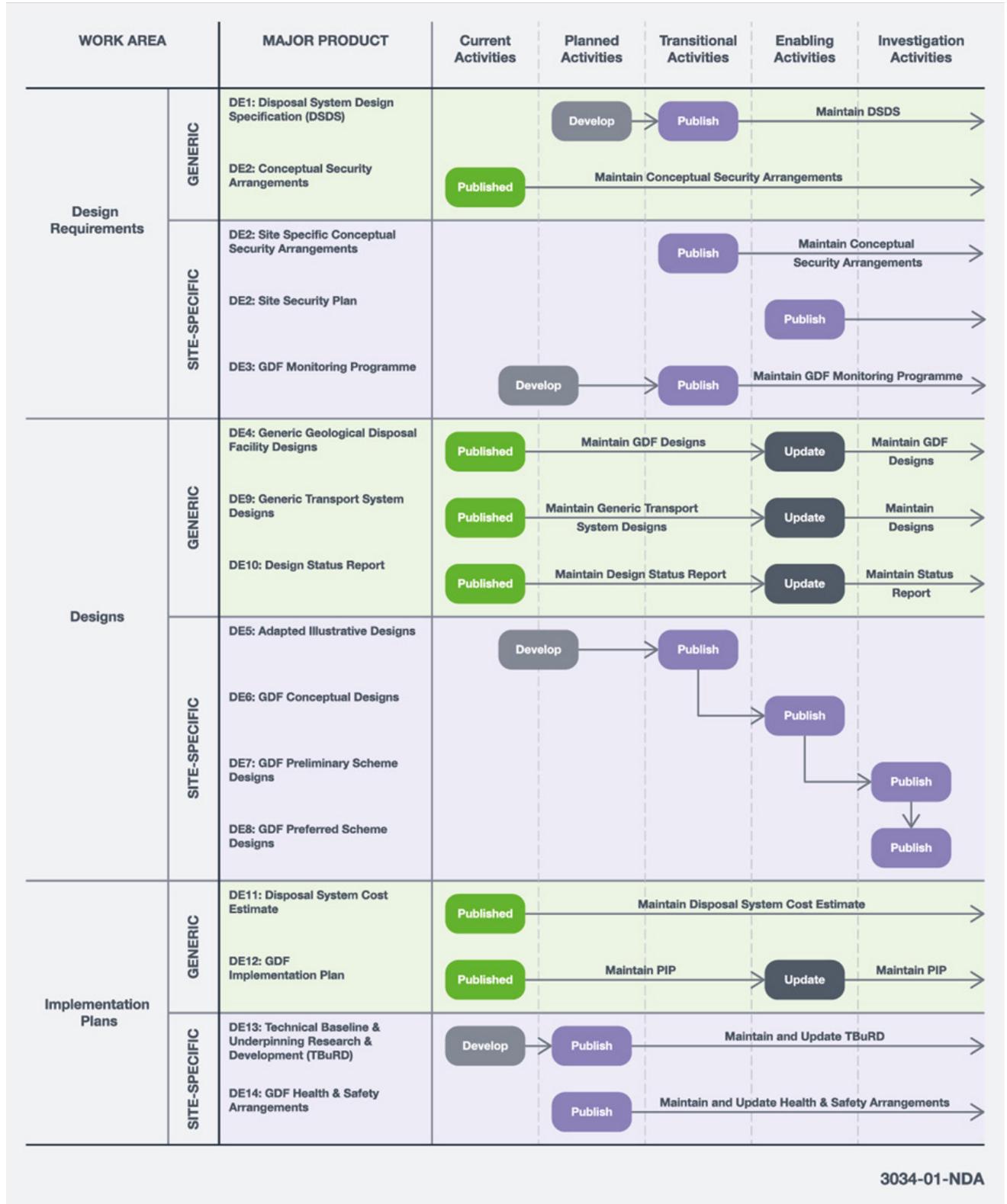
Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

Figure 15 Indicative schedule for the production of Major Products in the disposal system design work area



3034-01-NDA

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

## Disposal System Design Specification (Major Product DE1)

<p><b>Purpose</b></p> <p>To set out the detailed specifications for the disposal system, including the design, construction, operation, decommissioning and closure of the GDF.</p>	 <p><i>Computer representation of a possible design for the GDF waste receipt and handling area</i></p>	Specification																	
<p><b>Information needs and strategic objectives</b></p> <p>The DSDS will underpin design work at all stages of development, by allowing RWM to demonstrate the traceability and robustness of disposal system requirements and design compliance with these requirements.</p>																			
<p><b>Current Work Requirements</b></p> <p>Work is currently planned to integrate the DSS into a Requirements Management System (RMS) and in doing so, to set out the DSS within a hierarchy. The purpose of RWM’s RMS is to ensure that any product or design developed provides the user with the capability that was originally requested. Development of an RMS will provide the opportunity to review the clarity of definition of the requirements, logic linking between requirements, and whether some of the requirements currently residing within the DSS should actually be captured within the more detailed DSDS.</p> <p>In addition, there are a number of external stakeholders whose requirements may significantly impact upon a GDF; e.g. regulators. These requirements may have implications on both design and operations of a GDF and work is therefore planned to further develop the requirements in the DSS and to capture the appropriate requirements as soon as possible.</p> <p>The DSDS will be maintained within the same RMS as the DSS. RWM has adopted ‘IBM DOORS’ as the preferred software tool. Updated versions of the DSDS document will be issued periodically, as siting progresses, drawing on the latest design specifications held within the RMS.</p>	<p><b>Overview</b></p> <p>The DSS defines the requirements on the disposal system, as discussed under Major Product SP1.</p> <p>The disposal system design specification (DSDS) will set out the detailed specifications for the disposal system, including the design, construction, operation, decommissioning and closure of the GDF. The DSDS will describe how the engineering options or solutions for the design of the disposal system will be implemented in compliance with the requirements set out in the DSS.</p>	Design																	
<p><b>Longer Term Work Requirements</b></p> <p>The DSDS will be used to underpin the preparation of conceptual designs during site characterisation. As siting progresses and more site-specific information becomes available, the DSDS will provide a live record of requirements which will be updated as appropriate.</p> <p>Elements to be captured for each system requirement include the performance criteria and verification method. These will be used as the basis of an integrated test, evaluation and acceptance plan, which will itself be a major deliverable as siting progresses.</p>	 <p><i>The copper spent fuel disposal containers whose development by the Swedish operator, SKB, was supported by using an RMS</i></p>		Assessment																
<p><b>Drivers</b></p>	Underpinning Knowledge Base																		
<table border="1"> <tr> <td>Commercial / Contractual</td> <td></td> <td>Cost Impacts</td> <td></td> <td>Design Codes &amp; Standards</td> <td>✓</td> </tr> </table>		Commercial / Contractual		Cost Impacts		Design Codes & Standards	✓	<table border="1"> <tr> <td></td> <td>Disposal System Design</td> <td>✓</td> <td>Disposal System Specification</td> <td>✓</td> </tr> </table>		Disposal System Design	✓	Disposal System Specification	✓	<table border="1"> <tr> <td></td> <td>Environmental Safety Case</td> <td>✓</td> <td>Flexibility in Decision Making</td> <td></td> </tr> </table>		Environmental Safety Case	✓	Flexibility in Decision Making	
Commercial / Contractual			Cost Impacts		Design Codes & Standards	✓													
		Disposal System Design	✓	Disposal System Specification	✓														
		Environmental Safety Case	✓	Flexibility in Decision Making															
<table border="1"> <tr> <td>Disposal Concept Development</td> <td>✓</td> <td>Operational Safety Case</td> <td>✓</td> <td>Programme / Risk Management</td> <td>✓</td> </tr> </table>		Disposal Concept Development	✓	Operational Safety Case	✓	Programme / Risk Management	✓	<table border="1"> <tr> <td></td> <td>Regulatory Requirements</td> <td>✓</td> <td>Safety Case Methodology</td> <td>✓</td> </tr> </table>		Regulatory Requirements	✓	Safety Case Methodology	✓	<table border="1"> <tr> <td></td> <td>Siting Process (Voluntarism)</td> <td>✓</td> <td>Transport Safety Case</td> <td></td> </tr> </table>		Siting Process (Voluntarism)	✓	Transport Safety Case	
Disposal Concept Development		✓	Operational Safety Case	✓	Programme / Risk Management	✓													
		Regulatory Requirements	✓	Safety Case Methodology	✓														
	Siting Process (Voluntarism)	✓	Transport Safety Case																
<table border="1"> <tr> <td>Environmental Impact &amp; Sustainability</td> <td></td> <td>Stakeholder Engagement</td> <td>✓</td> <td></td> <td></td> </tr> </table>	Environmental Impact & Sustainability		Stakeholder Engagement	✓			<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						
Environmental Impact & Sustainability		Stakeholder Engagement	✓																
<table border="1"> <tr> <td>NDA Strategy</td> <td>✓</td> <td></td> <td></td> <td></td> <td></td> </tr> </table>	NDA Strategy	✓					<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						
NDA Strategy	✓																		
<table border="1"> <tr> <td>QA / Data Robustness</td> <td>✓</td> <td></td> <td></td> <td></td> <td></td> </tr> </table>	QA / Data Robustness	✓					<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						
QA / Data Robustness	✓																		
<table border="1"> <tr> <td>Site Assessment / Permissioning</td> <td>✓</td> <td></td> <td></td> <td></td> <td></td> </tr> </table>	Site Assessment / Permissioning	✓					<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						
Site Assessment / Permissioning	✓																		
<table border="1"> <tr> <td>Socioeconomic Impacts</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>	Socioeconomic Impacts						<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						<table border="1"> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>						
Socioeconomic Impacts																			

# S&T Programme – Disposal System Design Major Products

## Security Plans / Safeguards Arrangements (Major Product DE2)

Specification

### Purpose

To prevent theft of nuclear material or sabotage of nuclear facilities and protect sensitive technology, software and information.

### Information needs and strategic objectives

A GDF should be designed and constructed to provide appropriate physical security features to operate as a Category I facility (licensed for un-irradiated strategic nuclear material) from the outset, but it would operate initially as a Category III facility (appropriate for irradiated nuclear fuel) from first receipt of ILW and LLW.

During 2012, a security review of the GDF illustrative designs resulted in the production of the first GDF conceptual security arrangements document. This includes a description of the Level 1 'Operational Requirement' which specifies what a GDF security regime must be capable of protecting.

The conceptual security arrangements for the illustrative designs ensure the intended security regime reinforces, rather than conflicts with, existing designs which integrate operational and post-closure safety requirements.

### Current Work Requirements

The conceptual security arrangements document is currently being developed and is based on the illustrative designs. It is being developed with specialist supply-chain support and learning from the experiences of other SLCs and implementers of new nuclear power stations.

The site-specific conceptual security arrangements document will be produced during development of site-specific, adapted illustrative designs in the generic phase. This will be an updated, site-specific version of the security arrangements document.

### Longer Term Work Requirements

As more site-specific information becomes available the conceptual security arrangements document will be updated in parallel with GDF design development as shown in the figure on the next page.

During the surface-based investigations phase no formal regulatory submission for nuclear security is required. In this phase, the permissions schedule describes the production of a 'suite of other regulatory and stakeholder context documents' to be made available as a component of the delivery organisation's application for an environmental permit for intrusive investigations. A draft (Part 1) site security plan will be part of this suite. It is expected that there will be early regulatory liaison and opportunity for comment during the development of this document before it is finalised.

Prior to construction and underground-based investigations the first formal regulatory submission will be for a site security plan for regulatory approval at the same time as the grant of the initial nuclear site licence, i.e. before excavations for access routes.



### Overview

As a Prospective SLC RWM is subject to the UK's civil nuclear security regime, which requires adoption of a 'site security plan' approved by the Office for Nuclear Regulation (ONR).

A GDF security plan sets out measures to prevent theft of nuclear material or sabotage of nuclear facilities and identifies how sensitive nuclear technology, software and information will be protected. These arrangements cover physical security protection features such as fencing, CCTV, access controls, intruder alarms and the roles of the security-guard force and the Civil Nuclear Constabulary.

This Major Product comprises a suite of related documents that will be developed in turn, including conceptual security arrangements, site-specific conceptual security arrangements and site security plans.



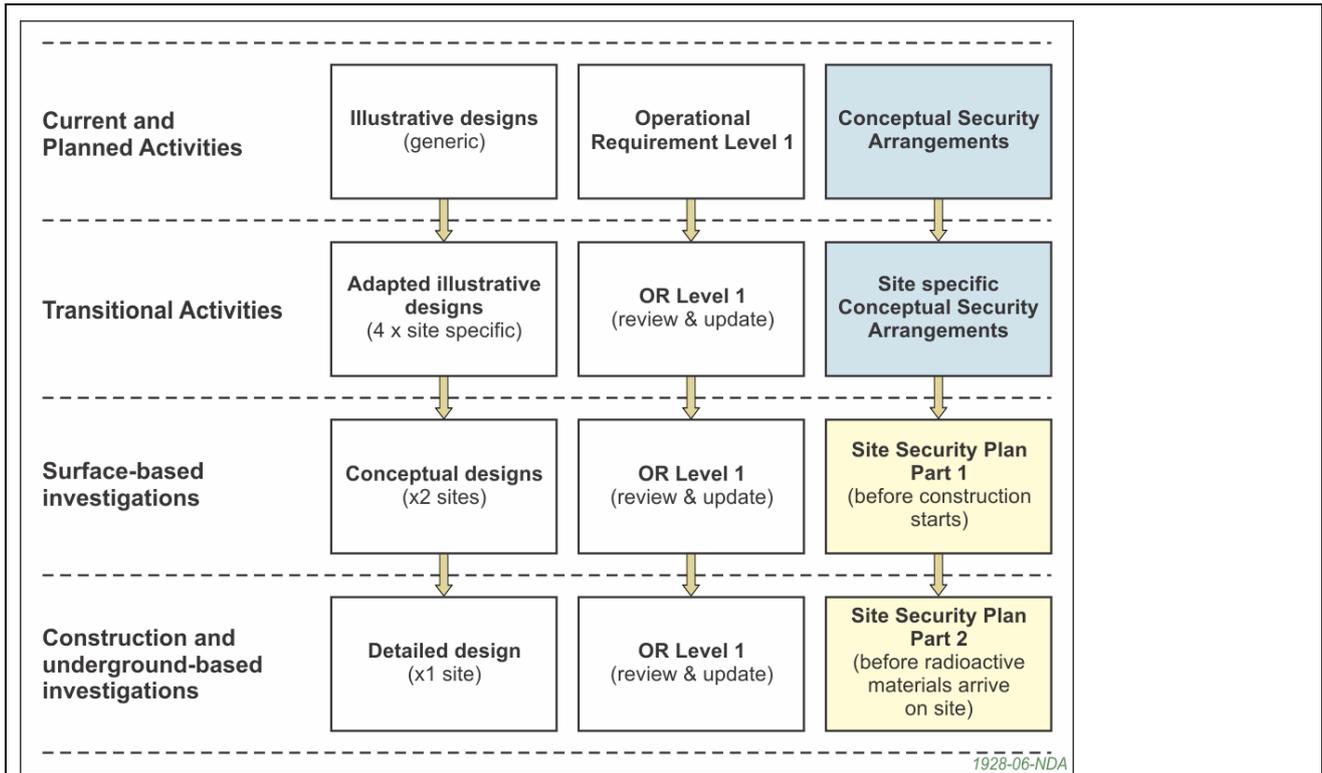
Vehicle Monitoring for Fissile Material

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products



Specification

Design

**Iteration of GDF Security Plans / Safeguard arrangements as the geological disposal programme progresses**

**Drivers**

Commercial / Contractual		Cost Impacts	✓	Design Codes & Standards	
Disposal Concept Development		Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making	
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement		Transport Safety Case	
Waste Package Disposability					

Assessment

**Notes:**

Since a GDF will be capable of disposing of Category I to III nuclear material, a security plan must be approved by the Civil Nuclear Security section within ONR, under the authority of the Nuclear Industries Security Regulations 2003 [1].

The conceptual security arrangements document supports the refinement of cost assessments and will also support identification and assessment of potential sites during RWM’s preparatory studies.

**References**

[1] The Nuclear Industries Security Regulations 2003, SI 2003/403.

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

## GDF Monitoring Programme (Major Product DE3)

Specification

### Purpose

To define the processes and parameters to be monitored, as part of a programme to address one or more monitoring objectives, and to identify techniques to be used for monitoring over the course of the GDF lifecycle.



*The surface environment around the GDF will be monitored using a range of equipment*

Design

### Information needs and strategic objectives

In the context of geological disposal of radioactive waste, ‘monitoring’ is defined by RWM as: *“Continuous or periodic observations and measurements of engineering, environmental, radiological or other parameters and indicators / characteristics, to help evaluate the behaviour of components of a geological disposal system, or the impacts of the system and its operation on people and the environment - and thus to support decision making during the disposal process and to enhance confidence in the disposal process.”*

Monitoring is undertaken to support the development of safety cases, for assurance of safety, and to demonstrate compliance with regulatory requirements. A monitoring programme is important both to RWM as the implementing body and also to RWM’s stakeholders, particularly:

- Safety authorities, who are likely to scrutinise the monitoring approach.
- Local communities and/or their representatives, who are likely to take a particular interest in monitoring to verify that protection goals are met. A monitoring programme can provide an effective mechanism for building stakeholder confidence in GDF implementation.

### Overview

Monitoring will be required during all phases of GDF implementation, i.e. during site investigation, construction, operation and closure. The data gathered during these phases will be used to support development of the operational and post-closure safety cases and to check compliance of activities with these safety cases.

RWM has developed an initial specification for a monitoring programme that will support the implementation of geological disposal. This specification is informed by the work of international collaborative projects on the topic of monitoring, and provides a framework for development of detailed aspects of the monitoring programme as GDF planning progresses.

Assessment

### Drivers

Disposal Concept Development		Disposal System Design	✓	Disposal System Specification	
Environmental Impact & Sustainability	✓	Environmental Safety Case	✓	Flexibility in Decision Making	
NDA Strategy		Operational Safety Case	✓	Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	✓

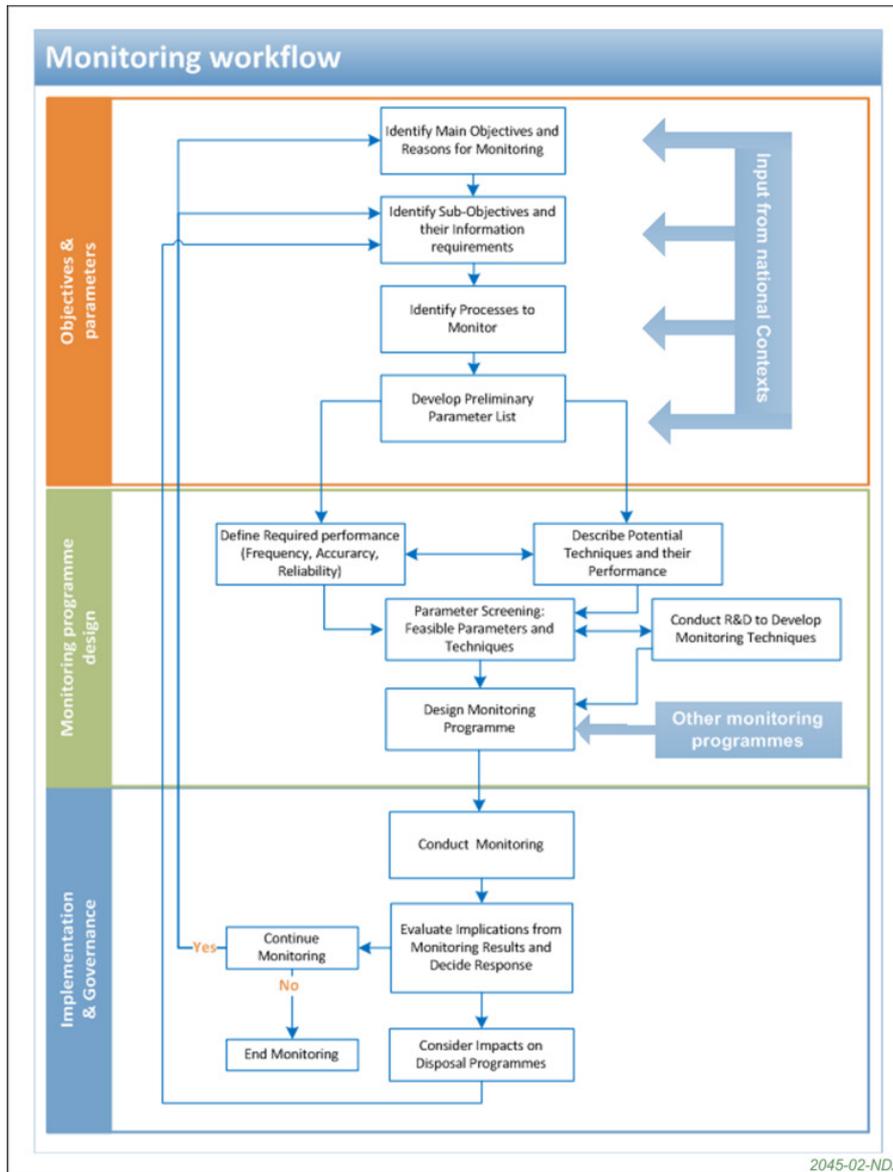
Underpinning Knowledge Base

### Current Work Requirements

RWM’s monitoring programme specification for a UK geological disposal system builds on lessons learned from the European Commission (EC) Monitoring Developments for Safe Repository Operation and Staged Closure (MoDeRn) Project, in which RWM was a partner. The figure on the next page was developed under the MoDeRn Project and illustrates a step-by-step reference framework for identifying what is required from monitoring and how these requirements will be developed into a monitoring programme.

# S&T Programme – Disposal System Design Major Products

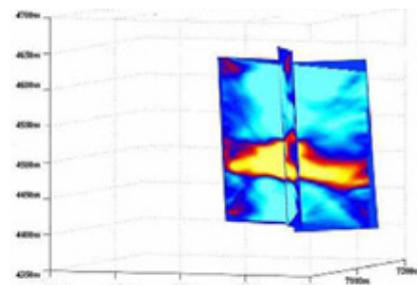
## Current Work Requirements (continued)



**The EC MoDeRn project monitoring workflow provides a framework for developing a GDF monitoring programme**

Based on an analysis of international guidance, regulatory requirements and internal drivers, RWM’s monitoring programme specification has been structured into seven sub-programmes, focusing on transport safety; construction safety; operational safety; post-closure safety; environmental assessment; socio-economic impact; and nuclear materials accountability and safeguards. Existing requirements on each sub-programme have been collated and parameters / disposal system components that could be monitored to address monitoring objectives associated with each sub-programme have been identified.

The monitoring parameters identified under each monitoring sub-programme will require amalgamation into an integrated monitoring programme. This will allow consideration and consolidation of overlaps, co-ordination of research into monitoring techniques, development of monitoring strategies, provide an integrated platform for management of monitoring data and ensure that the monitoring programme is pragmatic, efficient and does not introduce detrimental impacts on safety.



**Seismic tomography is one possible technique for monitoring the impact of the GDF on the surrounding geosphere**

Specification

Design

Assessment

Underpinning Knowledge Base

## S&T Programme – Disposal System Design Major Products

Specification

### Current Work Requirements (continued)

Having defined a monitoring programme specification, RWM's forward plans in this area are to:

- Develop the GDF monitoring programme, taking consideration of how best to demonstrate that safety functions are being fulfilled and noting that the objectives and scope of the monitoring programme will evolve through the implementation of geological disposal.
- Identify design requirements needed to meet the GDF monitoring programme.
- Incorporate these into the GDF illustrative designs.

RWM will continue to be actively involved in international collaborative initiatives on the topic of monitoring, to inform the ongoing development of its GDF monitoring programme. RWM is a partner in a new EC project on monitoring called "Development & demonstration of monitoring strategies and technologies for geological disposal" (MoDeRn 2020), which started in June 2015.

Design

### Longer Term Work Requirements

The monitoring programme specification will form an important aspect of the development of monitoring requirements set out in the Requirements Management System.

The GDF monitoring programme will be developed as the illustrative designs evolve into site-specific 'adapted' and 'conceptual' designs during the surface-based investigations. This will tailor the monitoring information requirements, techniques and performance requirements to site-specific conditions.

### References

- [1] EC MoDeRn, *Monitoring During the Staged Implementation of Geological Disposal: The MoDeRn Project Synthesis*, MoDeRn Deliverable D-6.1, January 2014.
- [2] Radioactive Waste Management Ltd, *Geological Disposal: Monitoring Programme Specification, Version 4*, 21509293, March 2014, publication pending.

Assessment

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

## Geological Disposal Facility Designs (Major Products DE4, DE5, DE6, DE7 & DE8)

### Purpose

To provide a design basis for safety assessments under RWM’s iterative disposal system development process.

### Information needs and strategic objectives

Developing generic designs allows representation of typical sizes of excavation, design of rock support, and design of disposal vaults or cells in a particular geology. Their use, and associated safety assessments, allows RWM to challenge its understanding and identify potential design improvements for the UK’s broad range of waste types.

Developing these designs helps, in turn, to enhance the understanding of how disposal could be carried out in different geological environments; how safety will be addressed in all phases of development; how long it might take to develop; what the environmental impacts of a implementing a GDF will be, and what it is likely to cost. The designs provide a basis for developing waste package specifications and, together with the GDF designs, allow the assessment of waste packaging proposals from waste producers to confirm they are consistent with the requirements currently foreseen for transport, operational and long-term safety of a GDF.

As the site selection process progresses, more detailed information on the geological environments, site-specific characteristics and design requirements will become available. There will be a need for the preparation of engineering designs, in increasing level of detail, to support this process. The design process has therefore been broken down into a number of stages to reflect this (as illustrated below). Hence, the design will progress from ‘illustrative design’, or generic GDF designs (Major Product DE4) through ‘adapted illustrative designs’ (DE5), ‘conceptual designs’ (DE6), ‘preliminary preferred scheme designs (DE7)’ and finally ‘detailed design’ or preferred scheme designs (DE8).

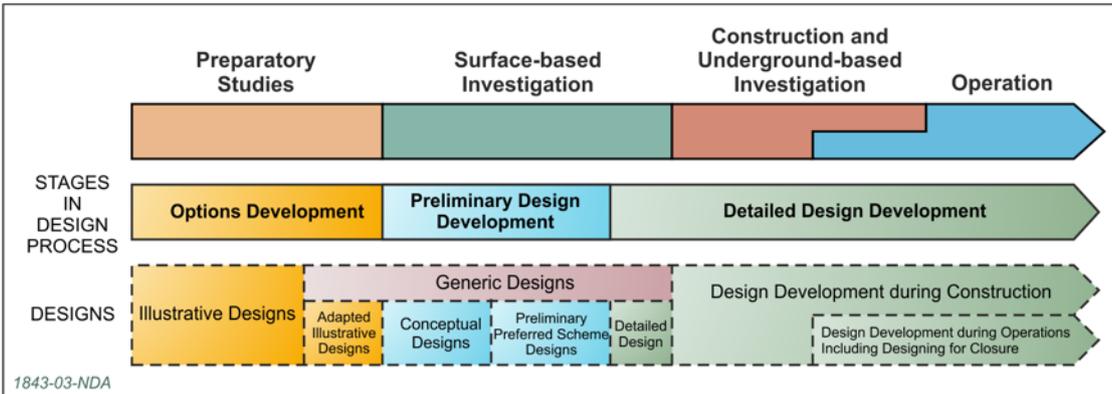


*A representation of the possible surface layout of the GDF*

### Overview

To underpin the generic DSSC, a range of geological disposal concepts have been evaluated, and illustrative designs have been developed for three generic geological environments representative of potential UK geological environments suitable for hosting a GDF for higher activity wastes.

The designs describe the design characteristics of a GDF and the processes of waste receipt and transfer, waste emplacement and finally backfilling and closure of a GDF. They have been developed from work done both in the UK and in international programmes.



### Drivers

Commercial / Contractual		Cost Impacts	✓	Design Codes & Standards	
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	
Environmental Impact & Sustainability	✓	Environmental Safety Case	✓	Flexibility in Decision Making	
NDA Strategy		Operational Safety Case	✓	Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

Specification

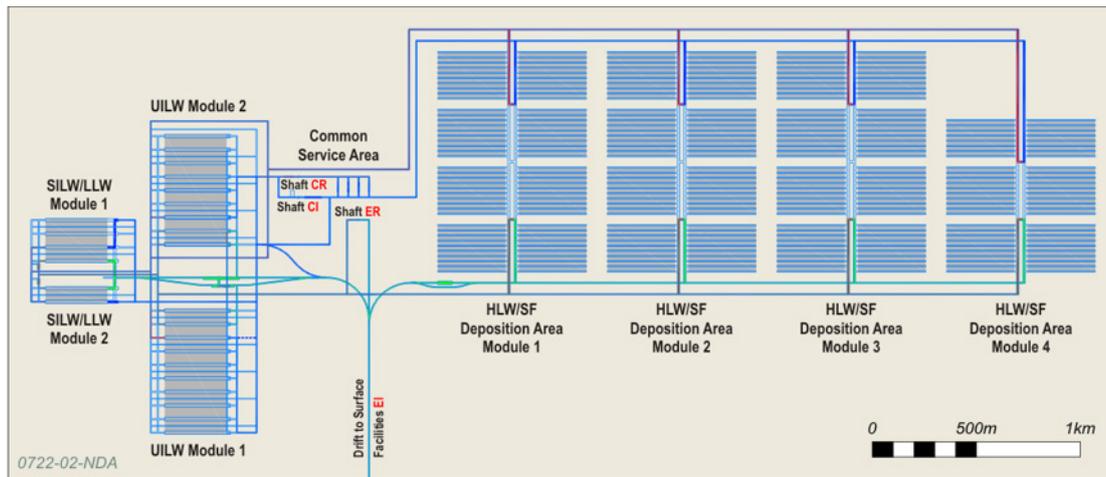
Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts	✓	Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability	✓				

## Current Work Requirements

The generic designs (Major Product DE4) were published to underpin the 2010 generic DSSC. An example design component, showing an illustrative layout for underground GDF facilities in a higher strength rock is shown below.

The generic designs will be updated and in due course site-specific designs will be developed as further engineering studies, outputs from research, and changes to legislation and associated design requirements become available and as the siting process progresses. This will be achieved through production of the related geological disposal facility design Major Products described below.

Design



### (a) Adapted Illustrative Designs (Major Product DE5)

The adapted illustrative designs require preparation of surface and underground layouts, including underground access arrangements. These designs will also include recognition of any construction / connection requirements from the GDF site to the surrounding supporting infrastructure. It is currently assumed that, other than the potential host geology type, the depth, the thickness, and potentially the extent and dip, little additional geological information will be provided. However, more detail of the surface facility location and its constraints will be available to inform the designs. These designs will be developed from the geological disposal concept option selected for each potential candidate site, adapted to the UK inventory and available site-specific data. The outputs of this work will include:

- Illustrations and layouts developed to align to surface and underground information and classes of wastes.
- Updated generic GDF design reports (as required, and noting that updates to these reports will be managed through change control as outlined under Major Product SP1).
- Updated design status reports for the key design elements / sub-systems of the design (as required).
- An initial disposal system design specification (DSDS).

Assessment

Underpinning Knowledge Base

## S&T Programme – Disposal System Design Major Products

<p><b>Longer Term Work Requirements</b></p> <p><b>(b) GDF Conceptual Designs (Major Product DE6)</b></p> <p>At the start of the surface-based investigation phase the design process will move from illustrative designs to conceptual designs. Using information from the initial phases of site investigation the conceptual designs will provide confidence that the GDF requirements can be achieved. Conceptual design development will involve identification and assessment of various design options against the available information. At this stage options which are not viable, or may be too limited in their application, will be eliminated. The GDF conceptual designs will require preparation of surface and underground designs, including the underground access arrangements and the connections to off-site infrastructure.</p> <p>A major area of activity by RWM during this stage will be the resolution of potential feasibility issues raised at “sub-system” level while maintaining the compliance of the overall GDF to the Disposal System Technical Specification. An example of a sub-system is the drift transport system, where an understanding of the relationship between drift gradient and transport options is required to support further design development. Information produced is expected to include general arrangement drawings, provisional layouts and design requirements. These will contain sufficient definition to demonstrate the engineering viability of the design options and include basic process flow diagrams, broad system definition and appropriate calculations to support further development and costing of the options, if and when required.</p>	Specification
<p><b>(c) Preliminary Scheme Designs (Major Product DE7)</b></p> <p>Developed from the conceptual designs, the GDF preliminary scheme designs will be prepared during intrusive surface-based investigations of the remaining candidate sites; at this stage it is currently assumed that three phases of borehole development will be undertaken and the availability of these data will facilitate the design development. GDF preliminary scheme designs will be prepared during the later investigations stage and refined in response to the emerging intrusive site investigation data. The objective of the preliminary scheme designs is to provide confidence that the GDF requirements are achievable based on information from the intrusive site investigations.</p> <p>The GDF preliminary scheme designs will underpin the required site-specific safety documentation, i.e. ongoing iterations of the Initial Site Evaluation and the initial development of the Preliminary Environmental Safety Evaluation. A comprehensive design review will also be undertaken by the Design Authority to check that the designs will form a sound basis for the data which will support the selection of a preferred site. Outputs will include:</p> <ul style="list-style-type: none"> <li>➤ Preparation of surface layouts, including designs for all surface buildings and infrastructure.</li> <li>➤ Underground layouts and access arrangements.</li> <li>➤ Construction and connection requirements from the GDF site to the supporting infrastructure.</li> <li>➤ Resolution of issues associated with the construction methodology.</li> </ul>	Design
<p><b>(d) Preferred Scheme Designs (Major Product DE8)</b></p> <p>The GDF preferred scheme designs will be prepared during surface-based investigations of the remaining candidate sites and will be iterations of the GDF preliminary scheme designs, using the additional site-specific information as it becomes available. The preferred scheme designs will support the site selection process, culminating in the selection of a preferred site and the applications for the start of underground investigations and construction. Outputs will include:</p> <ul style="list-style-type: none"> <li>➤ Surface layouts, including designs for all surface buildings and infrastructure, as well as underground layouts and access arrangements.</li> <li>➤ All construction and connection requirements from the geological disposal facility site to the supporting infrastructure.</li> <li>➤ Addressing any issues and uncertainties regarding the design, construction, operation and closure of the GDF.</li> </ul> <p>The preferred scheme designs will be used as the basis for the next iteration of design documentation, i.e. the detailed design.</p>	Assessment
	Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

## Generic Transport System Designs (Major Product DE9)

Specification

**Purpose**

To deliver packaged waste to the GDF in a manner that is safe, planned, timely, cost-effective, flexible, environmentally sound and robust against future changes.

**Information needs and strategic objectives**

The transport of radioactive waste has a crucial bearing on the safety cases that make up the generic Disposal System Safety Case. Developing transport system designs:

- Enhances understanding of how waste transfer from sites to a GDF could be carried out;
- Develops understanding of how safety can be addressed in all phases of waste transfer;
- Helps RWM to understand how long it might take to transport waste and what it is likely to cost.

This approach also provides a basis for developing waste package specifications. This then enables RWM to assess, using the established Letter of Compliance disposability assessment process, if waste packaging proposals from waste producers are consistent with the requirements currently foreseen for safe transport of packaged waste to a GDF.

**Current Work Requirements**

The generic TSD was published to support the 2010 generic DSSC. Updates to the generic TSD will become more detailed as further studies, research outputs and changes to legislation and the associated design requirements become available. As the site selection process progresses, the current issues and uncertainties with regards to the design and operation of the transport system for the geological disposal facility will be addressed.

**Longer Term Work Requirements**

The generic TSD will continue to be updated as required until the detailed design for a GDF is developed (i.e. into RWM’s Construction and Underground-based Investigations Phase).



*An example of a rail transport container that is currently in use*

**Overview**

The generic transport system design (TSD) defines what comprises the transport system and how the system could be operated. The transport system has been developed to support two key requirements:

- The transport of construction materials, spoil and personnel associated with building a GDF.
- The more specialised transport of the radioactive waste to a GDF.

The main objective of the radioactive waste transport system is to deliver packaged waste to a GDF in a manner that is safe, planned, timely, cost-effective, flexible, environmentally sound and robust against future changes. The transport system is designed to use any combination of rail, road and sea transport. As a site for a GDF has not been identified, development of a transport system must at this stage remain generic.

Liaison with the NDA strategic authority on transport, the ONR radioactive materials transport team, Civil Nuclear Security Programme and national rail companies will take place at all stages of development of the transport system to ensure that legislative and other drivers are met.

Design

Assessment

Underpinning Knowledge Base

**Drivers**

Commercial / Contractual		Cost Impacts	✓	Design Codes & Standards	
Disposal Concept Development		Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability	✓	Environmental Safety Case		Flexibility in Decision Making	
NDA Strategy	✓	Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts	✓	Stakeholder Engagement	✓	Transport Safety Case	✓
Waste Package Disposability	✓				

# S&T Programme – Disposal System Design Major Products

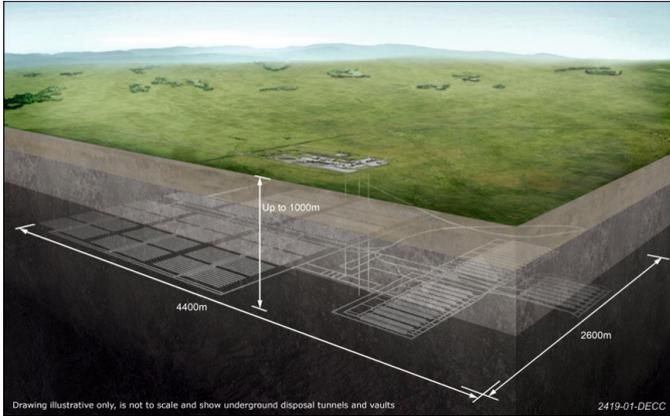
## Design Status Report (Major Product DE10)

**Purpose**  
To document the rationale behind the key historic design decisions and optimisation developments to date and provide a guide to the underpinning engineering work undertaken.

**Information needs and strategic objectives**  
The design status report will also form an underpinning document to RWM’s technical maturity analysis, which has been developed to provide transparency and visibility of the technical baseline for the construction, operation, closure of the GDF. This aligns with, but is separate from, the R&D Topic Status Reports (Major Products KB3 to KB18) which represent the scientific maturity underpinning the Disposal System Safety Case.

**Current Work Requirements**  
Following its initial publication in 2014, the Design Status Report will be maintained so as to capture our accumulating knowledge base in this area.

**Longer Term Work Requirements**  
As the GDF project progresses through the site selection process, the GDF conceptual designs will be developed into more detailed designs. It is currently assumed that the design status report will be updated as the design of the GDF progresses throughout the RWM work programme, capturing all of the key design developments and also capturing Best Available Technique (BAT).



*RWM’s design capability facilitates engagement with stakeholders via the production of computer aided design visualisations such as the Figure above*



*A tunnel being excavated for the new Crossrail-London Underground link*

**Overview**  
RWM has carried out a considerable amount of design development work in order to progress the GDF concept, determining the most appropriate layouts and construction methods. The purpose of the design status report is to document the rationale behind the key historic design decisions and optimisation developments to date and provide a guide to the underpinning engineering work undertaken.

The development of the design status report will enable stakeholders to locate information on key design developments and the justification for those developments.



*SKB’s prototype remotely operated spent fuel canister emplacement vehicle is an example of mature technology readily applicable to waste disposal concepts being considered in the UK*

Drivers					
Commercial / Contractual		Cost Impacts	✓	Design Codes & Standards	✓
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability	✓	Environmental Safety Case	✓	Flexibility in Decision Making	✓
NDA Strategy		Operational Safety Case	✓	Programme / Risk Management	✓
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

## Disposal System Cost Estimate (Major Product DE11)

Specification

**Purpose**  
To provide a best estimate of the overall cost and phasing of the GDF implementation programme.

**Information needs and strategic objectives**  
The GDF programme cost, also called the ‘disposal system cost estimate’, is a component of the total NDA nuclear provision. As such, it is updated annually and included in the NDA nuclear provision provided in the NDA Annual Report and Accounts.

The disposal system cost estimate also provides information about the cost of geological disposal to other waste producers outside the NDA estate, including EDF, as the operator of most UK nuclear power stations, and the Ministry of Defence. In addition it is used to support commercial interactions between the UK Government and prospective new nuclear power operators. The GDF programme cost estimate does not include the costs associated with the treatment, packaging, management (e.g. interim storage) and transport of wastes to the GDF, which are addressed by the waste producers.

**Current Work Requirements**  
As the GDF site selection process progresses more information will become available which will be used to provide updated estimates of the cost of implementing the programme. This approach will mitigate and reduce current uncertainties associated with the cost for the construction, operation and closure of the GDF.

**Longer Term Work Requirements**  
It is planned to produce updates to the Design System Cost Estimate throughout the future work programme. These will be aligned to updates to the GDF Implementation Plan (Major Product DE12) and the developing designs, leading to construction of the geological disposal facility.



*The NDA nuclear provision feeds into UK budget planning*

**Overview**

In order to plan the financing of the geological disposal programme and to inform the UK Government’s staged decision making process, RWM evaluates the potential cost of the geological disposal programme. The estimated cost includes all phases and all activities including research, design, construction, operation and closure.

The cost of the geological disposal programme is affected by many factors, but the most significant are the inventory of waste, the timing of waste arising, the timing and duration of each phase of implementation, the geology at the site of the GDF and the design of the GDF itself.

The disposal system cost estimate is contained in a cost brochure which includes all the cost information and metrics which underpin the overall estimate of the GDF programme. Cost estimates are able to be produced for a range of scenarios to reflect variation in the influencing factors outlined. However, the scenario used for estimating the nuclear provision is based on adopting the illustrative design applied in the higher strength rock geological environment.

Design

Assessment

Underpinning Knowledge Base

**Drivers**

Commercial / Contractual		Cost Impacts	✓	Design Codes & Standards	
Disposal Concept Development		Disposal System Design		Disposal System Specification	
Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making	
NDA Strategy		Operational Safety Case		Programme / Risk Management	✓
QA / Data Robustness		Regulatory Requirements		Safety Case Methodology	
Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement		Transport Safety Case	
Waste Package Disposability					

# S&T Programme – Disposal System Design Major Products

## GDF Implementation Plan (Major Product DE12)

### Purpose

To enable robust planning and management of GDF implementation, including management of the interfaces between GDF development activities by RWM and waste management / decommissioning activities at NDA sites.

### Information needs and strategic objectives

The GDF Implementation Plan (then called the PIP) was first produced in 2008 in response to a requirement from the NDA to develop a LTP to capture the scope, schedule and cost of managing all higher activity waste (HAW) in the UK through geological disposal. It was subsequently updated in 2009 to align it with the HAW inventory in the 2008 MRWS White Paper [1]. Following production of the PIP, which (as an internal working document) has not been published, “Geological Disposal: Steps towards implementation”, which uses much of the information from the PIP, was published in 2010 [2].

The GDF Implementation Plan enables robust planning and management of GDF implementation and includes provision for a staged approach, with clear decision points. Development of the GDF Implementation Plan requires any agreed changes that impact on the programme, cost, concept and design to be adopted in a controlled manner.

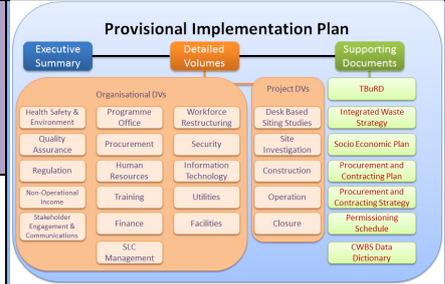
### Current Work Requirements

Many of the inputs and assumptions used to develop the 2009 PIP are out of date and do not reflect Government policy in the 2014 “Implementing Geological Disposal” White Paper [3]. In particular:

- The inventory for disposal set out in the 2014 White Paper results in an increase in the GDF footprint and extends the operational period of the GDF to around 150 years.
- The GDF and the associated boreholes are to be treated as nationally significant infrastructure projects (NSIP), and the land use planning process has therefore changed.
- The site identification, assessment and investigation steps set out in 2014 White Paper will affect the nature and timing of pre-construction activities (planning and site investigation).

The implications of recent policy changes on RWM’s long-term plans, as well as implications for waste producers, are currently being evaluated as part of RWM’s design development activities. Key steps in this process are expected to include:

- Development of a communication plan covering engagement with stakeholders including DECC and members of the GDF Users’ Group.
- Develop sub-programmes consistent with the 2014 White Paper for initial actions, site identification and site investigation.
- Assess the implications for the range of illustrative geological environments currently under consideration.
- Assess the implications for cost estimates for each draft programme.
- Consider the implications for waste owners of potential changes to waste dispatch schedules from the revised programmes.



**The current GDF Implementation Plan (referred to above as the Provisional Implementation Plan) comprises a number of documents**

### Overview

The NDA requires every SLC within its estate to describe the entirety of the activities required to take the associated site from its current state to the assumed or agreed end-state. This document is called a Lifetime Plan (LTP). However, as no site currently exists for a GDF, the level of programme certainty implied by an LTP was considered to be inappropriate for describing GDF implementation activities. As a result the equivalent to an LTP for RWM was agreed; this was originally called the GDF Provisional Implementation Plan (PIP), and is now referred to as the GDF Implementation Plan.

The GDF Implementation Plan adopts as much of the LTP methodologies, terminology and structure as possible, given the current status of the GDF implementation programme. It therefore describes the entirety of the activities required to take it forward from its present position, using an assumed programme for the construction of the illustrative GDF design in a higher strength rock. This allows interfaces with activities at other NDA sites to be considered and forms the basis for understanding the impact of any change in the scope, schedule and costs of GDF implementation plans.

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

Specification

<b>Longer Term Work Requirements</b>					
The above programme of work will inform decision-making on further development and update of the GDF Implementation Plan.					
<b>Drivers</b>					
Commercial / Contractual		Cost Impacts	✓	Design Codes & Standards	
Disposal Concept Development		Disposal System Design	✓	Disposal System Specification	
Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making	
NDA Strategy	✓	Operational Safety Case		Programme / Risk Management	✓
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability					
<b>References</b>					
[1] Defra, BERR, Welsh Assembly Government, Department of the Environment Northern Ireland, <i>Managing Radioactive Waste Safely: A framework for implementing geological disposal</i> , Cm7386, June 2008. ISBN 0101738625.					
[2] Nuclear Decommissioning Authority, <i>Geological Disposal: Steps Towards Implementation</i> , NDA Report NDA/RWMD/013, 2010.					
[3] Department of Energy and Climate Change, <i>Implementing Geological Disposal: A Framework for the long-term management of higher activity radioactive waste</i> , URN 14D/235, July 2014.					

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

## Technical Baseline and Underpinning Research & Development (TBUrd) (Major Product DE13)

<p><b>Purpose</b></p> <p>To ensure that the delivery of the NDA’s mission (as delivered through its sites and SLCs, including RWM as a prospective SLC) is technically underpinned by sufficient and appropriate R&amp;D.</p>	<p>Technology Readiness Levels (TRL)</p> <p>TRL9 Operations</p> <p>TRL8 Active Commissioning</p> <p>TRL7 Inactive Commissioning</p> <p>TRL6 Large Scale</p> <p>TRL5 Pilot Scale</p> <p>TRL4 Bench Scale Research</p> <p>TRL3 Proof of Concept</p> <p>TRL2 Invention and Research</p> <p>TRL1 Basic principles</p> <p><i>Technology Readiness Levels (TRLs) are used to evaluate the maturity of engineering design-based activities</i></p>	Specification																																				
<p><b>Information needs and strategic objectives</b></p> <p>Development of the RWM TBUrd submission, in addition to the other TBUrd submissions submitted to the NDA by its sites / SLCs, serves the following purposes:</p> <ul style="list-style-type: none"> <li>➤ Provides confidence in the technical deliverability of the SLCs’ plans.</li> <li>➤ Provides overall visibility of R&amp;D across the NDA estate to ensure strategically that appropriate R&amp;D is being carried out in a timely manner.</li> <li>➤ Identifies where drivers for co-ordinated / integrated R&amp;D may result from common needs, risks and opportunities.</li> <li>➤ Ensures key R&amp;D needs across NDA are identified, prioritised and work programmes are costed and scheduled in the Lifetime Plan (LTP)/ GDF Implementation Plan for individual sites / SLCs.</li> </ul>			Design																																			
<p><b>Current Work Requirements</b></p> <p>RWM is required to provide a TBUrd submission to the NDA on an annual basis. RWMs TBUrd submission has been developed in order to be compliant with the NDA’s Technical Baseline and Underpinning Research and Development Requirements (EGG10) guidance document [1]. The TBUrd submission consists of the following documentation:</p> <ul style="list-style-type: none"> <li>➤ A Technical Management Summary (TMS) detailing RWMs technical governance and assurance processes.</li> <li>➤ Process Wiring Diagrams (PWD) which highlight planned technologies and their maturities, taking a whole system approach.</li> <li>➤ An R&amp;D Table which details plans to resolve technical issues underpinning delivery.</li> <li>➤ A Technology Map giving a high level representation of the SLCs technology issues and opportunities.</li> </ul> <p>An Annual Technical Report (ATR) which details any changes in governance/assurance processes and any significant in-year changes to the baseline and R&amp;D requirements.</p>				Assessment																																		
<p><b>Overview</b></p> <p>Production of an RWM TBUrd (Technical Baseline and Underpinning Research and Development) submission is a requirement documented in the RWM-NDA Client Specification. Each of the NDA’s sites / SLCs is required to produce a TBUrd submission on an annual basis; as a prospective SLC, this requirement also applies to RWM.</p>		Underpinning Knowledge Base																																				
<p><b>Drivers</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>Commercial / Contractual</td> <td></td> <td>Cost Impacts</td> <td></td> <td>Design Codes &amp; Standards</td> <td></td> </tr> <tr> <td>Disposal Concept Development</td> <td></td> <td>Disposal System Design</td> <td style="text-align: center;">✓</td> <td>Disposal System Specification</td> <td></td> </tr> <tr> <td>Environmental Impact &amp; Sustainability</td> <td></td> <td>Environmental Safety Case</td> <td></td> <td>Flexibility in Decision Making</td> <td></td> </tr> <tr> <td>NDA Strategy</td> <td style="text-align: center;">✓</td> <td>Operational Safety Case</td> <td></td> <td>Programme / Risk Management</td> <td></td> </tr> <tr> <td>QA / Data Robustness</td> <td></td> <td>Regulatory Requirements</td> <td></td> <td>Safety Case Methodology</td> <td></td> </tr> <tr> <td>Site Assessment / Permissioning</td> <td></td> <td>Site Characterisation Results</td> <td></td> <td>Siting Process (Voluntarism)</td> <td></td> </tr> </table>			Commercial / Contractual			Cost Impacts		Design Codes & Standards		Disposal Concept Development		Disposal System Design	✓	Disposal System Specification		Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making		NDA Strategy	✓	Operational Safety Case		Programme / Risk Management		QA / Data Robustness		Regulatory Requirements		Safety Case Methodology		Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)
Commercial / Contractual			Cost Impacts		Design Codes & Standards																																	
Disposal Concept Development		Disposal System Design	✓	Disposal System Specification																																		
Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making																																		
NDA Strategy	✓	Operational Safety Case		Programme / Risk Management																																		
QA / Data Robustness		Regulatory Requirements		Safety Case Methodology																																		
Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)																																		

# S&T Programme – Disposal System Design Major Products

Specification

## Current Work Requirements

RWM is required to provide a TBuRD submission to the NDA on an annual basis. RWMs TBuRD submission has been developed in order to be compliant with the NDA’s Technical Baseline and Underpinning Research and Development Requirements (EGG10) guidance document [1]. The TBuRD submission consists of the following documentation:

- A Technical Management Summary (TMS) detailing RWMs technical governance and assurance processes.
- Process Wiring Diagrams (PWD) which highlight planned technologies and their maturities, taking a whole system approach.
- An R&D Table which details plans to resolve technical issues underpinning delivery.
- A Technology Map giving a high level representation of the SLCs technology issues and opportunities.

An Annual Technical Report (ATR) which details any changes in governance/assurance processes and any significant in-year changes to the baseline and R&D requirements.

Design

## Longer Term Work Requirements

RWM is required to provide a TBuRD submission to the NDA on an annual basis. The level of input may vary, depending on whether or not a major revision of the Technical Management Summary is required. The level of work required for the completion of the Process Wiring Diagrams, R&D Table, Technology Map and Annual Technical Report is currently assumed to be consistent year on year, but is dependent on the RWM work programme.

## References

[1] Nuclear Decommissioning Authority, *Technical Baseline and Underpinning Research and Development Requirements*, Document No. EGG10, Rev 6, November 2014.

Assessment

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

## GDF Health & Safety Arrangements (Major Product DE14)

### Purpose

The purpose of the Construction Phase Plan is to document the arrangements for managing any significant health and safety risks associated with the construction phase of the GDF. It is the basis for communicating these arrangements to all those involved in the construction phase.

The purpose of the Health and Safety File is to document any relevant health and safety information which should be taken into consideration during any subsequent project.

### Information needs and strategic objectives

#### Construction Phase Plan

The Construction Phase Plan should be prepared by the principal contractor (as defined under CDM 2015), taking into consideration pre-construction information and information provided with designs. Input may be required from the principal designer (as defined under CDM 2015).

The Construction Phase Plan should document health and safety arrangements for the construction phase, site rules and specific measures concerning work that falls within one or more of the categories listed in Schedule 3 of CDM 2015 (e.g. work on wells, underground earthworks and tunnels). The following topics should be included in the Construction Phase Plan:

- A description of the project such as key dates and details of key members of the project team.
- The management of the work including the health and safety aims for the project and site management arrangements, including:
  - The site rules.
  - Arrangements to ensure cooperation between project team members and coordination of their work, e.g. regular site meetings.
  - Arrangements for the protection of workers and control of site access.
  - Site induction.
  - Welfare facilities.
  - Fire and emergency procedures.
- The control of any of the specific site risks listed in Schedule 3, where they are relevant to the work involved.

#### Health and Safety File

The Health and Safety File should be prepared by the principal designer (as defined under CDM 2015), taking into consideration information in the Construction Phase Plan (addressing the management of health and safety during the construction phase), developed by the principal contractor (as defined under CDM 2015).

The Health and Safety File must contain information about the current project likely to be needed to ensure health and safety during any subsequent work, such as maintenance, cleaning, refurbishment or demolition. When preparing the Health and Safety File, information on the following should be considered for inclusion:

- A brief description of the work carried out.
- Any hazards that have not been eliminated through the design and construction processes, and how they have been addressed (e.g. surveys or other information concerning asbestos or contaminated land).
- Key structural principles (e.g. bracing, sources of substantial stored energy – including pre- or post-tensioned members) and safe working loads for floors and roofs.



**All activities at the GDF will be subject to health and safety regulations**

### Overview

In order to ensure that there are appropriate health and safety arrangements in place during the GDF construction phase, and during subsequent activities at a GDF, there is a requirement under the Construction (Design and Management) Regulations 2015 (CDM 2015) for RWM to produce a Construction Phase Plan and a Health and Safety File.

As the “client” for the “project” to construct a GDF (these terms being defined in CDM 2015), RWM must ensure that a Construction Phase Plan is drawn up before construction begins. RWM must also ensure that a Health and Safety File is prepared, and updated during the construction phase.

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Disposal System Design Major Products

Specification

- Hazardous materials used (e.g. lead paints and special coatings).
- Information regarding the removal or dismantling of installed plant and equipment (e.g. any special arrangements for lifting such equipment).
- Health and safety information about equipment provided for cleaning or maintaining the structure.
- The nature, location and markings of significant services, including underground cables; gas supply equipment; fire-fighting services etc.
- Information and as-built drawings of the building, its plant and equipment (e.g. the means of safe access to and from service voids and fire doors).

## Drivers

Commercial / Contractual	✓	Cost Impacts	✓	Design Codes & Standards	
Disposal Concept Development		Disposal System Design	✓	Disposal System Specification	
Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making	
NDA Strategy		Operational Safety Case	✓	Programme / Risk Management	✓
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability					

Design

## Current Work Requirements

Work is required to develop an appropriate scope, structure and format for both the Construction Phase Plan and the Health and Safety File. This work will build on industry good practice, while recognising the scale and unprecedented duration of the construction, operational and closure activities of a GDF. This is needed to ensure that all relevant information will be accessible when required throughout the lifetime of the GDF.

## Longer Term Work Requirements

Development of the Construction Phase Plan and the Health and Safety File are mainly considered to be longer term needs, since their development will be specific to the detailed design and location of a GDF (taking into consideration site-specific information).

Through working with the principal contractor, RWM must ensure that the Construction Phase Plan has been drawn up before the construction phase begins. RWM must also ensure that the plan is regularly reviewed, and revised where necessary.

The Health and Safety File is a live-document, and should therefore be updated during the project by the principal designer. In conventional construction projects, once the project is finished, the client should expect the principal designer to pass them the Health and Safety File. However, due to the nature of the GDF project, where construction activities will be ongoing for a number of decades, suitable processes must be in place to ensure the Health and Safety File is maintained.

Assessment

## References

[1] *Construction (Design and Management) (CDM) Regulations 2015.*

Underpinning Knowledge Base

## S&T Programme – Assessments Major Products

### 6 Major Products in the assessments work area

RWM carries out assessment activities in four broad areas:

- Safety assessments and the production of safety cases** (Major Products AS1 to AS8). The objectives of assessing safety are to understand and illustrate the range of possible behaviours of the disposal system, to build confidence in this understanding, and to identify knowledge gaps to be addressed in future work. A safety case is the written documentation demonstrating that risks associated with a site, a plant, part of a plant or a plant modification are as low as reasonably practicable and that the relevant standards have been met. Safety cases for licensable activities at nuclear sites are required under the Nuclear Installations Act. Regulatory guidance indicates the need to submit formal safety evaluations / safety cases at certain points in the GDF development and implementation process. RWM carries out a range of assessment activities in the meantime to illustrate how a GDF would provide safety and periodically publishes a disposal system safety case (DSSC) reflecting its understanding.
- Environmental and socio-economic assessments** (Major Products AS9 to AS12). Assessments in this area focus on evaluating the environmental and socio-economic effects of implementing geological disposal and consulting with stakeholders on how to manage these effects. Some of the Major Products under this heading will be “non-statutory” documents, developed to support constructive engagement with communities participating in the siting process for a GDF and to help select sites for intrusive surface-based investigations (i.e. boreholes). Other Major Products will be statutory documents, produced specifically to support Development Consent applications for boreholes.
- Waste packaging assessments** (Major Products AS13 to AS15). RWM conducts the disposability assessment process and issues Letters of Compliance (LoCs) in order to provide guidance to waste producers on the measures that can be taken to convert higher activity wastes into a passively safe form (‘packaged’) whilst providing confidence that the packaged wastes will be transportable to, and disposable at, a future GDF.
- Site assessments** (Major Products AS16 to AS20). RWM will produce various assessment reports to inform decision making during the GDF siting process. The scope of Major Products in this area is currently under review, following publication of the 2014 *Implementing Geological Disposal* White Paper [2]. The White Paper sets out a number of initial actions that will be undertaken by the UK government and the developer (RWM), including developing and implementing a process of national geological screening; developing a process of working with communities; and establishing a policy framework for planning decisions. In parallel with its input to delivery of these initial actions, RWM is undertaking preparations to ensure that it is ready to launch the siting process in 2017 and to engage effectively with potentially interested communities. This ongoing preparatory work will feed into an internal planning document referred to as the Siting Process Implementation Plan. A range of Major Products will be required in this area. Those that are currently planned are presented in this document; others are likely to be identified as planning for the siting process progresses.

The assessments work area has 20 Major Products associated with it, as shown in Figure 16. The indicative schedule for producing these Major Products is shown in Figure 17.

Specification

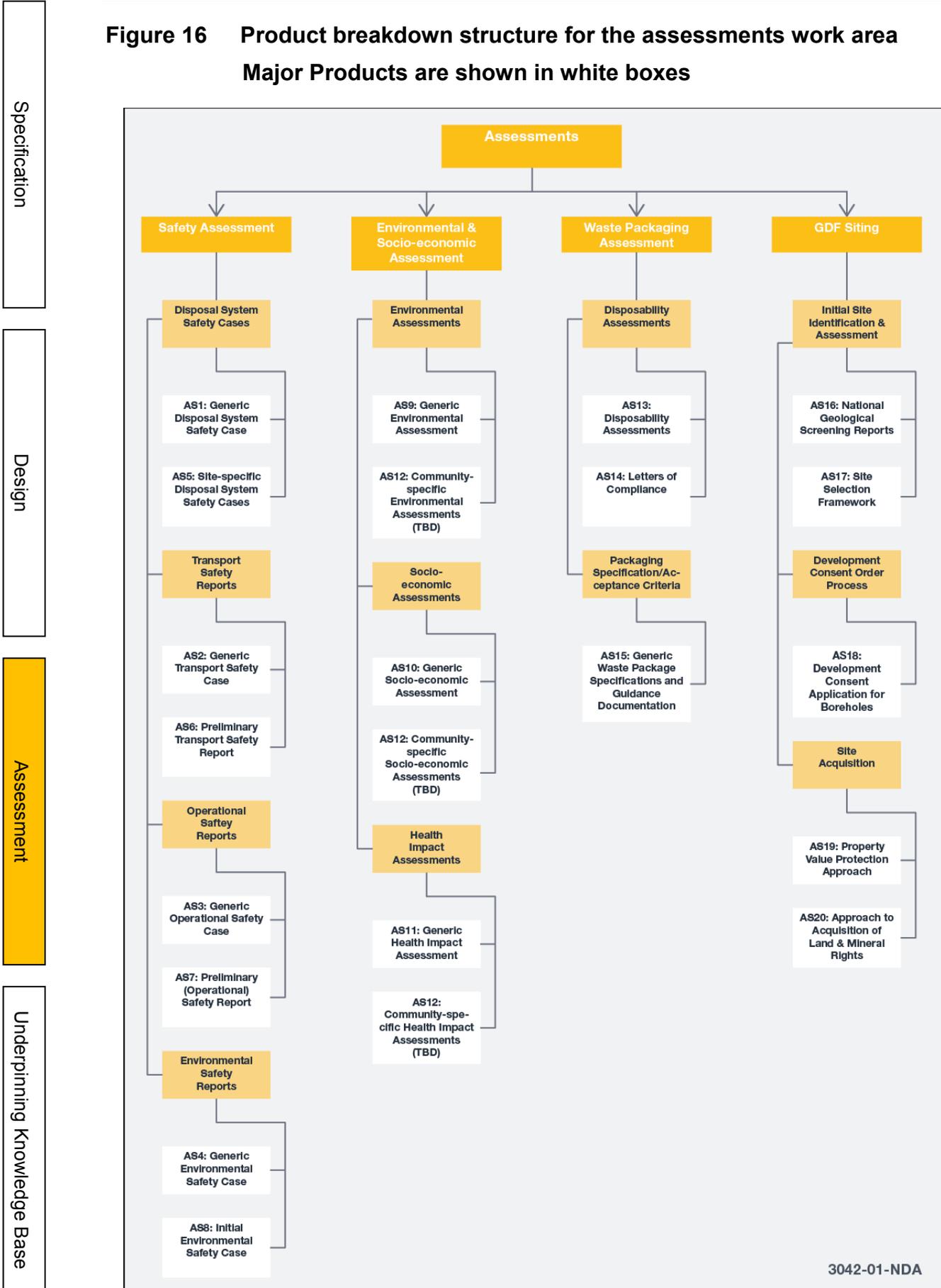
Design

Assessment

Underpinning Knowledge Base

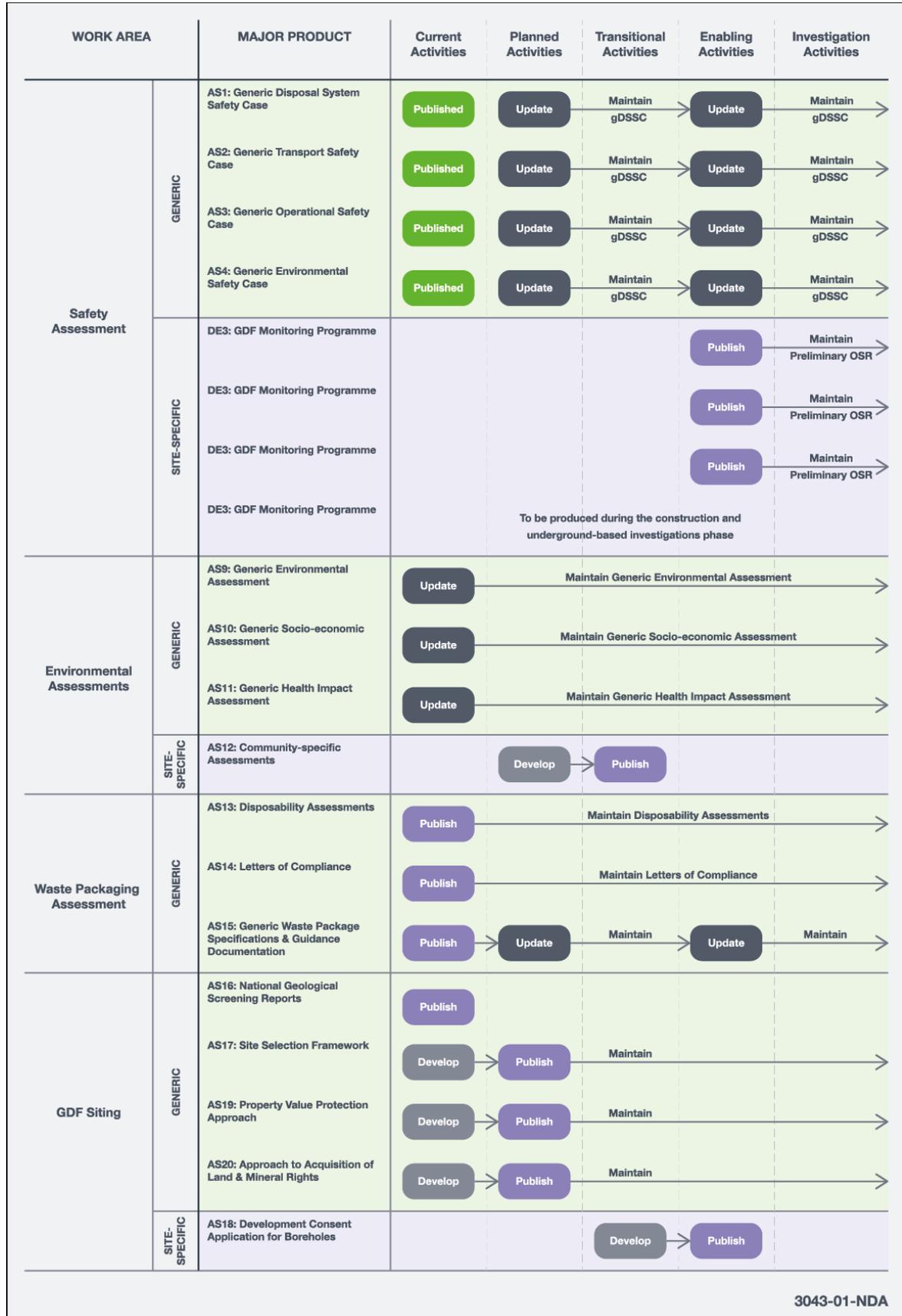
# S&T Programme – Assessments Major Products

Figure 16 Product breakdown structure for the assessments work area  
Major Products are shown in white boxes



# S&T Programme – Assessments Major Products

Figure 17 Indicative schedule for the production of Major Products in the Assessments work area



Specification

Design

Assessment

Underpinning Knowledge Base

3043-01-NDA

# S&T Programme – Assessments Major Products

## Generic Disposal System Safety Case (Major Product AS1)

Specification

### Purpose

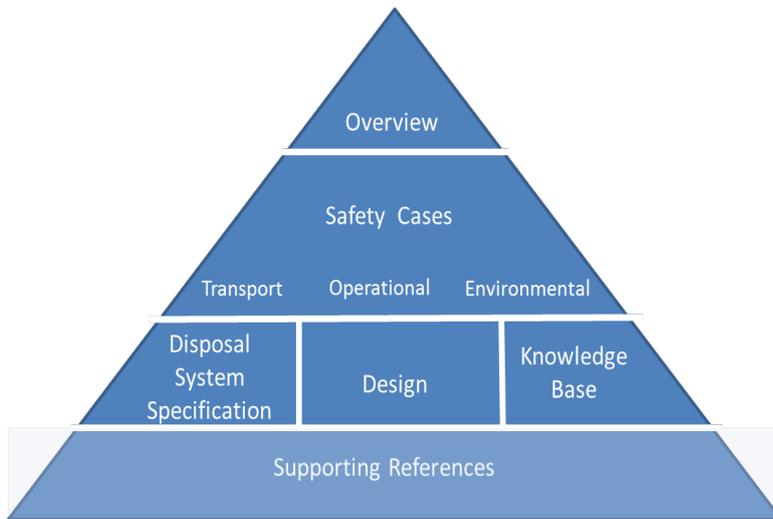
The generic Disposal System Safety Case sets out to demonstrate that each of the transport, construction, operation and closure activities will be safe and that the facility will continue to remain safe after it has been closed.

### Information needs and strategic objectives

The generic DSSC and supporting reports support the objectives to develop the specification, design, safety case and environmental and sustainability assessments for the disposal system and obtain regulatory support. The gDSSC also provides the boundary conditions upon which RWM can assess the disposability of waste packages.

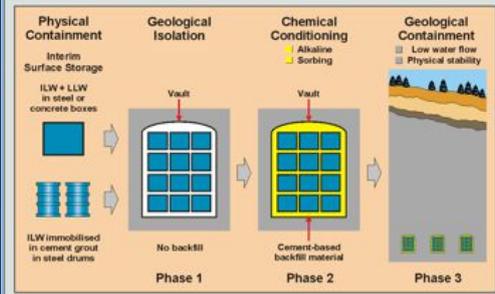
The generic DSSC is the embodiment of the application of RWM's business model, whereby RWM develops a requirement-led DSS leading to designs, safety cases, assessments and an R&D programme through an iterative process, and use and develop a knowledge base of the science, technology and engineering to support geological disposal of UK higher activity waste. The generic DSSC provides a snapshot in time of this business model in action.

Design



**Hierarchical structure of the gDSSC**

Assessment



**A schematic showing a generic concept for the disposal of ILW packages**

### Overview

The generic disposal system safety case (DSSC) considers the safety of higher activity waste (HAW) transport, the safety of the construction and operation of the GDF, and the safety of the disposal facility in the very long term, after it has been sealed and closed.

The generic DSSC (gDSSC) is hierarchical in structure, comprising an overview, individual safety case reports and supporting reports. The intent is that the structure provides increasing levels of detail for readers that wish to explore the supporting technical and scientific evidence base. However, the generic DSSC is primarily written for the UK regulators.

Each of the components of the generic DSSC is a Major Product. The intent of this description of the generic DSSC Major Product is to highlight it and to provide directions to the component part Major Products which are described in detail later in this report.

Underpinning Knowledge Base

### Drivers

Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development		Disposal System Design		Disposal System Specification	
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	✓
NDA Strategy		Operational Safety Case	✓	Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	✓
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	✓
Waste Package Disposability	✓				

## S&T Programme – Assessments Major Products

<p><b>Current Work Requirements</b></p> <p>The generic DSSC was published in 2010 and a second issue is planned to be ready for publication in FY 2016/17. Documents that comprise the generic DSSC will be maintained “live”, meaning that further work will be undertaken to address known issues and to respond to feedback from regulators and stakeholders. In cases where the additional work enables RWM to close-out issues or to provide an improved description of the current position or future plans, RWM will propose to update the individual documents, which may be by publication of an addendum or by reissue of the document(s). In either case this will be controlled by the RWM change control procedure.</p> <p>In some cases changes to one document will have knock-on effects and lead to a need to change other documents within the DSSC suite. The change control process recognises this eventuality and provides a mechanism for the implications of changes to be identified and fully addressed. This may, in some instances, require update or revision to be made to more than one report or require the production of an additional report that gets incorporated into the suite.</p> <p>Many of the Major Products that make up the generic DSSC describe work being carried out to address identified information needs, feedback from regulators and stakeholders or to address issues raised by them. The individual Major Product descriptions should be consulted for this level of detail.</p>	Specification
<p><b>Longer Term Work Requirements</b></p> <p>The generic DSSC suite will be maintained throughout the site selection process until RWM has sufficient confidence in the site-specific safety cases and it is decided that the generic DSSC is no longer necessary. The site-specific safety cases will therefore be developed as a separate and parallel work stream to the generic DSSC. This approach will facilitate the development and licensing of a GDF whilst safeguarding the generic basis of the ‘Letter of Compliance’ disposability assessment process and also recognising the possibility of alternative sites coming into the process.</p>	Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

## Generic Transport Safety Case (Major Product AS2)

Specification

### Purpose

To demonstrate that the transport operations to move radioactive waste from the waste producers’ sites to the site of a GDF can be achieved safely and to support transport requirements of RWM’s disposability assessment process.

### Information needs and strategic objectives

Responsibility for radioactive waste transport rests with the waste producers. However, to facilitate an integrated approach to waste transport and provide assurance to stakeholders, RWM will assume responsibility for development and assessment of the transport system design. A decision has yet to be made whether RWM will, in the future, have any additional responsibilities. RWM will demonstrate safety of the transport operation through production of a TSC.

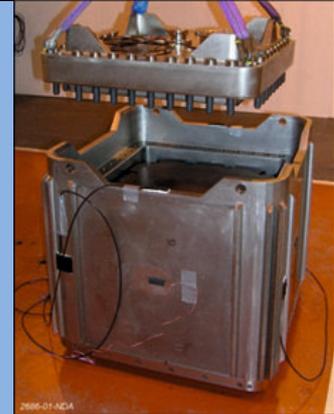
Information needs addressed by the generic TSC fall into three types:

- Information describing the current understanding of the safety of transport operations to move radioactive waste from the waste producers’ sites to the site of a GDF.
- Identification of the uncertainties and knowledge gaps relating to aspects of transport safety that will need to be studied further, in order to develop an improved understanding of the safety of transport operations. These knowledge gaps are translated into task sheets in the S&T Plan.
- Provision of information in support of RWM’s work with waste producers to deliver packaging solutions via the LoC disposability assessment process, and the production of waste package specifications and guidance documentation. Safe transport, including the performance of waste packages in a range of hypothetical accidents, is a key aspect of LoCs.

The generic TSC main report summarises the safety arguments set out in the TPS and the generic TSSA. The contents of these reports are as follows:

- The TPS report describes the UK and international safety regime, including measures that are (or will be) in place to ensure that waste will be moved safely and in accordance with regulations. It describes the proposed arrangements for packaging wastes for transport and those put in place by RWM to underpin the necessary transport package approvals.
- The generic TSSA presents information on the overall transport system envisaged and provides a preliminary radiological safety assessment, estimating the levels of radiological dose to workers (package handlers, crane operators, railway workers) in routine transport operations. Consideration is given to transportation by road, rail and sea.

Various supporting reports underpin the generic TSC. The transport system design and design status report (Major Products DE9 and DE10) are particularly relevant, as are research status reports on criticality safety (Major Product KB16 & KB17) and waste package accident performance (Major Product KB15).



**Transport containers are rigorously tested to ensure their integrity, using scale models**

### Overview

The generic transport safety case (TSC) demonstrates that transport operations to move radioactive waste from the waste producers’ sites to a GDF can be achieved safely, with radiation exposures below allowable limits and in accordance with UK statutory provisions. It provides information on transport operations as currently envisaged and sets out why RWM has confidence that transport can be accomplished safely.

The generic TSC comprises a Tier 1 report: the generic TSC main report, and two Tier 2 reports: The Transport Package Safety (TPS) report and the generic Transport System Safety Assessment (TSSA).

There is no regulatory requirement to produce a TSC. The TPS report sets out how formal regulatory requirements will be met. Nevertheless, RWM wishes to set out its transport arrangements in this way, so that stakeholders can be assured about its plans.

Design

Assessment

Underpinning Knowledge Base

### Drivers

Commercial / Contractual		Cost Impacts		Design Codes & Standards	✓
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	✓
Waste Package Disposability	✓				

# S&T Programme – Assessments Major Products

<p><b>Notes:</b> The principal requirements for the radiological safety of radioactive materials transport are contained in the International Atomic Energy Agency (IAEA) Transport Regulations [1], which are then translated into EU and UK legislation. These establish four basic requirements founded on long-established International Basic Safety Standards:</p> <ul style="list-style-type: none"> <li>➤ Material must be adequately contained under routine, normal and accident conditions of transport.</li> <li>➤ Protection from radiation exposure must be provided by limiting the radiation levels emanating from a package.</li> <li>➤ Heat emitted from the decay of the radioactive material must be dissipated safely.</li> <li>➤ Fissile contents must be controlled in such a way that sub-criticality is maintained at all times under normal and accident conditions of transport.</li> </ul> <p>The provisions of the IAEA Transport Regulations are incorporated into the United Nations Model Regulations for the Transport of Dangerous Goods [2]. In the UK they are implemented for road or rail by the Carriage of Dangerous Goods Regulations 2009, and by the Merchant Shipping (Dangerous Goods and Marine Pollutant) Regulations 1997 [3] and through The Dangerous Substances in Harbour Areas Regulations 1987 [4] for transport by sea.</p>	Specification
<p><b>Current Work Requirements</b></p> <p><b>(a) Maintain and update the generic TSC</b></p> <p>The generic TSC was first published in 2010 and a second issue is planned to be ready for publication in FY 2016/17. Further work will be undertaken to address known issues and to respond to regulatory / stakeholder feedback, with updates / addenda published as required. The following topics are being addressed:</p> <ul style="list-style-type: none"> <li>➤ Continued development of package design safety reports (PDSRs) for the complete family of transport packages.</li> <li>➤ Continued development of the approach for demonstrating criticality safety during transport.</li> <li>➤ Assessment of the radiological dose uptake by workers as an input to the design of the transportation system.</li> <li>➤ Continued support to the LoC disposability assessment process where specific proposals are challenging or require change to existing transport plans.</li> </ul> <p><b>(b) Maintain and update the transport safety toolkits</b></p> <p>The TSC is supported by a number of software tools (referred to as toolkits), which can be used to check that waste package designs are acceptable; the transport safety toolkits support the LoC disposability assessment process. The toolkits used for this purpose will be maintained in order to accommodate changes to requirements and new waste package (or transport package) designs that may be introduced.</p> <p><b>(c) Develop and maintain the transport safety manual</b></p> <p>A transport safety manual (TSM) has been developed, which forms part of RWM’s management system and sets out the default procedures, methodologies and guidance for producing the documents that make up the TSC. The TSM links to other RWM corporate management arrangements, in particular those for production and assessment of safety cases and the design manual. The TSM will be kept under review and updated as necessary to reflect learning from its application and suggestions for additions and/or areas for improvement. The principal audience of the TSM is the safety case document authors, but regulators or other stakeholders may also have an interest.</p>	Design
<p><b>Longer Term Work Requirements</b></p> <p>The generic TSC and overall generic DSSC will be maintained throughout the site selection process until RWM has sufficient confidence in the site-specific safety cases and decides that the generic DSSC is no longer necessary. The site-specific safety cases will therefore be developed as a separate and parallel work stream to the generic DSSC. This approach allows for the development and licensing of a GDF whilst safeguarding the generic basis of the LoC disposability assessment process whilst recognising the possibility of alternative sites coming into the process.</p>	Assessment
<p><b>References</b></p> <p>[1] IAEA, Regulations for the Safe Transport of Radioactive Material 2009 Edition. IAEA Safety Standards Series No. TS-R-1. IAEA, Vienna, 2009.</p> <p>[2] The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations, 2009, SI 2009/1348.</p> <p>[3] The Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations, 1997, SI 1997/2367.</p> <p>[4] The Dangerous Substances in Harbour Areas Regulations, 1987, SI 1987/37.</p>	Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

## Generic Operational Safety Case (Major Product AS3)

Specification

### Purpose

To demonstrate that the engineered design will be to a high safety standard and will be robust against potential faults.

### Information needs and strategic objectives

The generic OSC demonstrates that the GDF design will be safe and will protect workers and the public. It also supports RWM’s strategic objective to work with waste producers to deliver optimum waste packaging solutions.



**Roof-collapse is a key operational safety risk; rock-bolting will help to reduce this risk**

Design

The generic OSC sets out RWM’s baseline understanding of the feasibility of constructing and operating a GDF that meets safety standards and expectations set out by regulators and by relevant legislation. The generic OSC takes the DSS and generic designs as its starting point and addresses the safety of construction, operations and closure by considering hazards and consequential pathways that may lead to radiological dose to workers and members of the public.

In undertaking disposability assessments for specific waste package designs RWM determines whether proposed waste packages will have characteristics compliant with the generic OSC or whether changes are required, either to the waste package design or to the generic GDF design and safety case.

Despite being at an early stage, the existing generic OSC applies methods and approaches in line with regulatory expectations for a nuclear safety case and in this manner takes the first step in building confidence that a GDF for higher activity wastes can be constructed, operated and closed safely. The generic OSC considers potential radiological impacts to workers and the public, from both normal day-to-day operations and from fault conditions during the operational period. This is done in order to ensure that a GDF is designed in such a way as to reduce routine exposure so far as is reasonably practicable and within acceptable limits. Similarly, the design is scrutinised from the earliest stages to identify potential hazards and the faults which might cause them to be realised. Safety specialists and designers work together during the development of the design in order to eliminate, by design, as many potential faults as possible. Where this is not possible, sufficient protection and safety systems will be incorporated in the design, to ensure that the consequences and risks associated with any fault condition are within acceptable limits.

### Overview

The aim of the generic operational safety case (OSC) is to demonstrate that the GDF design will be:

- Engineered to a high safety standard.
- Robust against potential faults such that the associated risks are restricted to levels that are as low as reasonably practicable (ALARP).

The generic OSC is not responding to a formal legal or regulatory requirement, but provides assurance that, in due course, RWM will be able to make a site-specific safety case for a GDF that will satisfy all regulatory requirements. In doing so it explains how RWM will protect operators and members of the public from hazards arising during normal and fault conditions.

The generic OSC comprises a Tier 1 report: the generic OSC main report, and the following Tier 2 reports:

- Vol. 1: Construction and Non-Radiological Safety Assessment.
- Vol. 2: Normal Operations Operator Dose Assessment.
- Vol. 3: Accident Safety Assessment.
- Vol. 4: Criticality Safety Assessment.
- The generic Operational Environmental Safety Assessment (OESA) report.

Assessment

Underpinning Knowledge Base

### Drivers

Disposal Concept Development		Disposal System Design	✓	Disposal System Specification	✓
NDA Strategy		Operational Safety Case	✓	Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability	✓				

# S&T Programme – Assessments Major Products

<p><b>Current Work Requirements</b></p> <p><b>(a) Maintain the generic OSC</b></p> <p>The generic OSC was first published in 2010 and a second issue is planned to be ready for publication in FY 2016/17. Further work will be undertaken to address known issues and to respond to regulatory / stakeholder feedback, with updates / addenda published as required. The following topics are being addressed:</p> <ul style="list-style-type: none"> <li>➤ Continued development of the understanding of dose uptake by workers through normal waste package receipt and emplacement operations. This requires further interaction with designers on shielding and residence times.</li> <li>➤ Further assessment of the dose uptake implications for GDF workers and the public due to naturally occurring radon gas and gases collected and discharged from the active ventilation system.</li> <li>➤ Further iteration with designers and researchers to improve understanding waste package performance under impact and fire accident conditions and to determine any mitigation measures to be incorporated in the design.</li> <li>➤ Continued development of the understanding of operational safety issues associated with criticality.</li> <li>➤ Continued development of methodologies and approaches for design basis accident analysis, probabilistic safety assessment and human factors in line with regulatory guidance and expectations.</li> <li>➤ Development of improved understanding of release mechanisms, transport and uptake pathways and design mitigation for radioactivity discharged from the site either through effluent streams or as direct radiation shine.</li> <li>➤ Continued support to the LoC disposability assessment process where specific proposals are challenging or require change to existing designs and operational safety assessments.</li> </ul> <p><b>(b) Maintain the operational safety toolkit</b></p> <p>The generic OSC includes both qualitative and quantitative assessment methods to build up an overall safety case for the facility. The quantitative assessment methods take inventory data from the Derived Inventory and, in combination with waste package performance data, calculate potential doses to workers and the public for comparison against corporate radiological targets and limits. These calculations are undertaken within a purpose designed software “toolkit”. The toolkit is also used to check that specific waste package designs introduced via RWM’s disposability assessment process are compatible with the quantitative assessments and hence with the generic safety case. The toolkit used for this purpose needs to be maintained up to date to ensure that it maintains compatibility with any changes to the safety case methods and/or to changes in corporate dose limits or regulatory guidance. The toolkit may also need to be updated in the event that new waste package designs are developed or introduced through the LoC disposability assessment process.</p> <p><b>(c) Development of the nuclear operational safety manual (NOSM)</b></p> <p>A nuclear operations safety manual (NOSM) has been developed, which forms part of RWM’s management system and sets out the default procedures, specifications, criteria, methodology and guidance for producing the documents that make up the OSC. The NOSM covers all stages of OSC development including construction, commissioning, operations, decommissioning and closure. In the short-term RWM will concentrate on those aspects of the NOSM required for maintaining the generic OSC and for planning the early site-specific safety case stages. The NOSM will be kept under review and updated as necessary to reflect learning from its application and suggestions for additions and/or areas for improvement. The principal audience of the NOSM is the safety case document authors, but regulators or other stakeholders may also have an interest.</p>	<p>Specification</p>
<p><b>Longer Term Work Requirements</b></p> <p>The generic OSC and overall generic DSSC will be maintained throughout the site selection process until RWM has sufficient confidence in the site-specific safety cases and decides that the generic DSSC is no longer necessary. The site-specific safety cases will therefore be developed as a separate and parallel work stream to the generic DSSC. This approach allows for the development and licensing of a GDF whilst safeguarding the generic basis of the LoC disposability assessment process and recognises the possibility of alternative sites coming into the process.</p> <p>In view of the need for both the OSC and ESC to consider the impacts of radiation discharged from the site as a result of routine operations, future development of the OESA is considered as part of the generic OSC development.</p>	<p>Design</p>
	<p>Assessment</p>
	<p>Underpinning Knowledge Base</p>

# S&T Programme – Assessments Major Products

## Generic Environmental Safety Case (Major Product AS4)

Specification

### Purpose

To demonstrate the environmental safety of the disposal of radioactive waste in a GDF.

### Information needs and strategic objectives

Information needs addressed by the generic ESC fall into three types:

- First, the generic ESC describes RWM’s approach to developing the safety methodology and arguments needed for an ESC.
- Second, the generic ESC identifies the uncertainties and knowledge gaps relating to aspects of assessing environmental safety that will need to be studied further.
- Third, the generic ESC directly supports RWM’s strategic objective to work with waste producers to deliver optimum packaging solutions for higher activity wastes, which is delivered through the LoC disposability assessment process and the production of waste package specifications and guidance documentation. In undertaking disposability assessments RWM determines whether packaged wastes will have characteristics compliant with the assessment basis used in the generic ESC and ultimately whether the wastes could be accommodated within a GDF post-closure safety case, i.e. that the packages are ‘disposable’.



*The ESC must demonstrate the ability to protect the surface environment*

### Overview

The generic environmental safety case (ESC) collates the claims concerning the environmental safety of the disposal of radioactive waste in a GDF, substantiated by a structured collection of arguments and evidence. It needs to address environmental safety at the time of disposal and in the long-term, after wastes have been emplaced and the facility has been closed. The generic ESC is based on an approach to assessing performance of a GDF by representing the hydrogeological setting in a way that would be widely applicable in the UK.

The generic ESC is supported by operational and post-closure environmental safety assessments (the OESA and PCSA, respectively). The OESA will follow standard practice for nuclear plants, and will be updated based on site-specific considerations as the GDF programme is implemented. The key challenge for development of the generic ESC therefore resides with the PCSA.

The generic ESC does not respond to a formal legal or regulatory requirement but provides assurance that, in due course, RWM will be able to make a site-specific ESC for a GDF that will satisfy all regulatory requirements.

Design

The generic ESC:

- Demonstrates the viability, and ultimately the safety, of the proposed disposal approach, including RWM’s understanding of the performance of multiple barrier systems, and how the different environmental safety functions provided by each component work together to provide safety in the long-term.
- Supports site identification and site assessment and provides a generic baseline safety case understanding to support a future Environmental Permit application.
- Integrates and analyses information so as to guide research, design and site characterisation programmes during GDF siting.
- Supports RWM’s disposability assessment process, including the production of waste packages in support of legacy waste clean-up by demonstrating how the design of wasteform and waste container will provide the necessary post-closure safety functions.
- Has been produced as a platform to support dialogue and demonstrate the safety of geological disposal during GDF siting, wherever a generic approach is required.

Assessment

Underpinning Knowledge Base

### Drivers

Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability	✓				

# S&T Programme – Assessments Major Products

<p><b>Notes:</b></p> <p>The generic ESC is primarily written for the UK environmental regulators (the Environment Agency), and responds to published regulatory guidance known as the guidance on requirements for authorisation of radioactive waste disposal (the “GRA”) [1]. RWM’s generic ESC addresses the fundamental protection objective contained in the GRA, stated as: “...to ensure that all disposals of solid radioactive waste to facilities on land are made in a way that protects the health and interests of people and the integrity of the environment, at the time of disposal and in the future, inspires public confidence and takes account of costs.”</p>	Specification
<p><b>Current Work Requirements</b></p> <p>Recognising that the GRA sets out a staged-approach, RWM’s strategy has been to start formulating safety arguments at a high level, based on understanding of the performance of a generic site. As GDF siting progresses, the level of detail and specificity of these safety arguments will increase. The generic ESC follows the GRA as best it can at this early stage and addresses all the identified principles and requirements, encompassing management, radiological and technical aspects of the safety case for a GDF.</p> <p>The following activities are required during the planned and transitional activities.</p> <p><b>(a) Maintain the generic ESC</b></p> <p>The generic ESC was first published in 2010 and a second issue is planned to be ready for publication in FY 2016/17. Further work will be undertaken to address known issues and to respond to feedback from regulators and stakeholders, with updates / addenda published as required. The following topics are being addressed:</p> <ul style="list-style-type: none"> <li>➤ Consideration of revised document structures to improve accessibility to key safety arguments and make it easier for readers to follow the “golden thread” into underpinning Status Reports and other key references. Work in this area includes development of the safety “narrative” describing RWM’s understanding of how the various safety functions provided by components of a disposal system interact and provide safety in different geological settings.</li> <li>➤ Further development of the treatment of uncertainty and how this should be taken into account in quantitative models of radionuclide transport and uptake in the biosphere.</li> <li>➤ Continued development of modelling capability and methods addressing disposal system behaviour and evolution, at component and total-system level. This also includes consideration of how current approaches would need to develop for application in site-specific cases.</li> <li>➤ Continued development of modelling techniques to support safety arguments on the impact of gases generated in the GDF near-field.</li> <li>➤ Continued development of approaches and methods for addressing human intrusion and external events such as glaciation and climate change.</li> <li>➤ Continued development of models and methods for sensitivity and scoping studies and for application to specific waste package designs to determine required contributions to post-closure safety functions.</li> <li>➤ Development of assessment methods to demonstrate protection of the environment from hazardous substances and non-hazardous pollutants that may be disposed of in waste packages.</li> </ul>	Design
<p>Changes to the generic ESC will also arise through changes to the disposal system specification, from R&amp;D activities, through the identification of novel waste packaging proposals as part of the LoC disposability assessment process or through upstream optimisation. Changes to the generic ESC will be managed through RWM’s change control process.</p> <p><b>(b) Development of the Environmental Safety Case manual</b></p> <p>An environmental safety manual (ESM) has been developed, which forms part of RWM’s management system and sets out the default procedures, methodologies and guidance for producing the documents that make up the ESC. The ESM links to other RWM corporate management arrangements, in particular those for production and assessment of safety cases and the design manual. The ESM will be kept under review and updated as necessary to reflect learning from its application and suggestions for additions and/or areas for improvement. The principal audience of the ESM is safety case document authors, but regulators or other stakeholders may also have an interest.</p>	Assessment

Specification

Design

Assessment

Underpinning Knowledge Base

## S&T Programme – Assessments Major Products

Specification

### Longer Term Work Requirements

As with other components of the generic DSSC, the generic ESC will be maintained until RWM has sufficient confidence in site-specific safety cases and decides that generic work is no longer necessary. Site-specific safety cases will therefore be developed as a separate and parallel work stream. This approach allows for the development and licensing of a GDF whilst safeguarding the generic basis of the LoC disposability assessment process and recognising the possibility of alternative sites to enter the GDF siting process at a later date.

### References

[1] Environment Agency, Geological Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation, February 2009.

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

## Site-specific Disposal System Safety Cases (Major Product AS5)

<p><b>Purpose</b></p> <p>A site-specific DSSC sets out to demonstrate that each of the transport, construction, operation and closure activities at a given site will be safe and that the GDF will continue to provide safety after it has been closed.</p>		 <p><i>Observations in the underground environment will allow the DSSC to reflect site-specific conditions</i></p> <p><b>Overview</b></p> <p>In order to license the GDF the regulatory structure in the UK requires RWM to follow a twin-track regulatory process seeking environmental permits from the Environment Agency under the Environmental Protection Act (EPA 2010) and seeking nuclear site licence permissions under the Nuclear Installations Act. This will influence the manner in which RWM decides to structure site-specific safety cases, which it will start to develop and submit during the surface-based and construction / underground investigation phases.</p> <p>In line with the generic DSSC it is envisaged that a site-specific DSSC will comprise a suite of documents, many of which will be Major Products in their own right. The intent of this description of the site-specific DSSC Major Product is to highlight the overall scope of a site-specific DSSC and to provide directions to the component part Major Products which are described in on subsequent pages of this report.</p>																																			
<p><b>Information needs and strategic objectives</b></p> <p>A site-specific DSSC, like the generic DSSC, will provide a snapshot of the evolving safety case, together with the associated design and evidence base for a particular site. The information needs and strategic objectives for the site-specific DSSC are described in more detail for the three site-specific safety assessment Major Products (AS6, AS7 and AS8).</p> <p>A structure that can easily be used by the intended recipient (i.e. the regulators) should be an enduring aim of the DSSC. It is intended therefore that the current approach whereby a DSSC comprises a Transport Safety Case (TSC), Operational Safety Case (OSC) and an Environmental Safety Case (ESC), together with supporting reports will continue. The generic DSSC also aims to present an integrated safety case and this too is an important aim that RWM plans to continue; to this end, the OSC is the means for delivering the initial state for the post-closure ESC and an integrated approach should feature a ‘hand-shake’ between these two safety cases.</p>																																					
<p><b>Current Work Requirements</b></p> <p>The work required for the site-specific DSSC is described in the site-specific safety assessment Major Products (AS6, AS7 and AS8).</p> <p>The generic DSSC and supporting Major Products will be maintained for as long as necessary until RWM has sufficient confidence in site-specific safety cases and decides that generic work is no longer needed. Site-specific safety cases will therefore be developed as a separate and parallel work stream. This approach allows for the development and licensing of a GDF whilst safeguarding the generic basis of the LoC disposability assessment process and recognising the possibility of alternative sites to enter the GDF siting process at a later date.</p>																																					
<p><b>Longer Term Work Requirements</b></p> <p>The development of the site-specific DSSC through the RWM work programme is described in the site-specific safety assessment Major Products (AS6, AS7 and AS8).</p>																																					
<p><b>Drivers</b></p> <table border="1"> <tr> <td>Environmental Impact &amp; Sustainability</td> <td></td> <td>Environmental Safety Case</td> <td>✓</td> <td>Flexibility in Decision Making</td> <td></td> </tr> <tr> <td>NDA Strategy</td> <td></td> <td>Operational Safety Case</td> <td>✓</td> <td>Programme / Risk Management</td> <td>✓</td> </tr> <tr> <td>QA / Data Robustness</td> <td></td> <td>Regulatory Requirements</td> <td>✓</td> <td>Safety Case Methodology</td> <td>✓</td> </tr> <tr> <td>Site Assessment / Permissioning</td> <td>✓</td> <td>Site Characterisation Results</td> <td></td> <td>Siting Process (Voluntarism)</td> <td>✓</td> </tr> <tr> <td>Socioeconomic Impacts</td> <td></td> <td>Stakeholder Engagement</td> <td>✓</td> <td>Transport Safety Case</td> <td>✓</td> </tr> <tr> <td>Waste Package Disposability</td> <td>✓</td> <td></td> <td></td> <td></td> <td></td> </tr> </table>		Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making		NDA Strategy		Operational Safety Case	✓	Programme / Risk Management	✓	QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	✓	Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	✓	Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	✓	Waste Package Disposability	✓				
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making																																	
NDA Strategy		Operational Safety Case	✓	Programme / Risk Management	✓																																
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	✓																																
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	✓																																
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	✓																																
Waste Package Disposability	✓																																				

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

## Preliminary Transport Safety Report (Major Product AS6)

Specification

### Purpose

To inform stakeholders of RWM’s plans for the transportation of higher activity wastes from waste producers to the GDF.

### Information needs and strategic objectives

Responsibility for radioactive waste transport rests with the waste producers. However, to facilitate an integrated approach to waste transport and provide assurance to stakeholders, RWM will assume responsibility for development and assessment of the transport system design and represent the interests of the waste producers at an early stage. A decision has yet to be made on whether RWM will, in the future, have any additional responsibilities. RWM will demonstrate safety of the transport operation through production of a TSC.

Production of the preliminary transport safety report is not a regulatory requirement. However, RWM recognises that radioactive waste transport is a major concern to many stakeholders and that there is a need to initiate early communication with local communities and stakeholders affected by the transport operations. The main driver for this Major Product is therefore the need to inform stakeholders of plans for transport to the site(s) under consideration and to set out the plans and processes for providing a safe transport system, as a basis for engaging in dialogue with potentially affected parties.

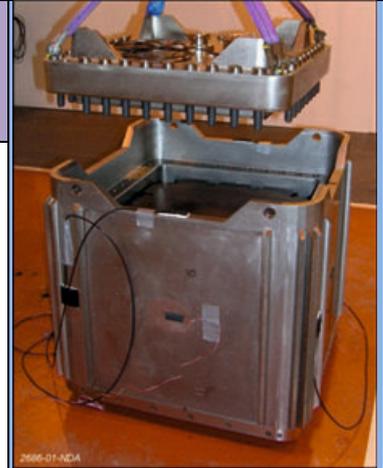
The preliminary transport safety report will fulfil an important role in supporting the ISE as well as application for an environmental permit for intrusive site investigation, by describing proposed arrangements for transport of radioactive waste materials to a GDF located at one of the sites under consideration. Such a document will provide relevant information to stakeholders and to ONR, who will ultimately regulate the transport arrangements for radioactive materials.

### Current Work Requirements

No work is required to prepare the preliminary transport safety report until surface-based investigations begin.



*Rail, road and sea options will be considered for transport to the GDF*



*A 1/3 scale model of a Shielded Waste Transport Container (SWTC) (without thermal shields)*

### Overview

As progress is made in site selection it is anticipated that, when the surface-based investigations phase is reached, RWM will wish to commence intrusive site investigations at candidate sites. RWM’s proposals for site investigation will require environmental permitting by the Environment Agency following consideration of an Initial Site Evaluation (ISE) (see Major Product KB22). It is anticipated that a preliminary transport safety report will support the ISE, addressing transport safety for the particular site under consideration. This will therefore be the first of an expected series of site-specific transport safety cases.

Design

Assessment

Underpinning Knowledge Base

### Drivers

QA / Data Robustness		Regulatory Requirements		Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts	✓	Stakeholder Engagement	✓	Transport Safety Case	✓

# S&T Programme – Assessments Major Products

## Preliminary (Operational) Safety Report (Major Product AS7)

**Purpose**  
 To demonstrate how the management, construction and operation of a GDF will be undertaken so as to protect people, plant and the environment from any hazards or harmful consequences



*A view of underground conditions at ANDRA's Bure research facility in France*

**Information needs and strategic objectives**  
 Production of a 'Preliminary Safety Case' is an expectation within regulatory guidance [1] and will be an important step towards demonstrating to ONR that RWM has the necessary corporate competences to hold a nuclear site licence. It will enable ONR to take an informed view of any potential operational safety issues that may arise through the planning process or through stakeholder interactions. At the early design stage regulators state that the purpose of the 'Preliminary Safety Case' is:

- To make a statement of intent to construct and operate a nuclear facility.
- To demonstrate that the plant in principle is capable of being constructed and managed safely throughout all life cycle changes.
- To discuss the significant options and define and justify the ones chosen.
- To indicate the safety criteria and objectives.
- To provide a broad demonstration that in principle the criteria are likely to be achieved.

The PSR will also fulfil an important role in supporting the application for an environmental permit and associated land-use planning applications for intrusive site investigation by describing RWM's proposed approach for managing, constructing and operating the GDF in a manner that protects workers and the public from any hazards or harmful consequences.

RWM currently plans that PSRs will be produced for each candidate site. Such a document will provide relevant information to stakeholders and the ONR, who RWM anticipate will ultimately licence the construction and operation of the facility under the Nuclear Installations Act.

**Overview**  
 When the surface-based investigations phase is reached, RWM will wish to commence intrusive site investigations at remaining candidate sites. RWM's proposals for site investigation will require environmental permitting by the Environment Agency following consideration of an Initial Site Evaluation (ISE) (Major Product KB22).

A preliminary operational safety report will support the ISE, addressing operational safety for the particular site under consideration. This will therefore be the first of an expected series of site-specific operational safety cases.

**Current Work Requirements**  
 No work is required to prepare the preliminary operational safety report until surface-based investigations begin.

**Longer Term Work Requirements**  
 The PSR will consider the safety of construction, commissioning, operations, decommissioning, backfilling, final sealing and closure of the GDF in line with regulatory expectations; once prepared, it will be maintained throughout the GDF siting process.

Drivers					
NDA Strategy		Operational Safety Case	✓	Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	

**References**  
 [1] ONR, Guidance on the Purpose, Scope and Content of Nuclear Safety Cases, T/AST/051, Issue 001, May 2002.

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

Specification

Design

Assessment

Underpinning Knowledge Base

## Initial Environmental Safety Case (Major Product AS8)

**Purpose**  
 To support the necessary environmental and planning applications to construct a GDF by demonstrating how environmental safety will be maintained throughout construction, operation, closure and post-closure.

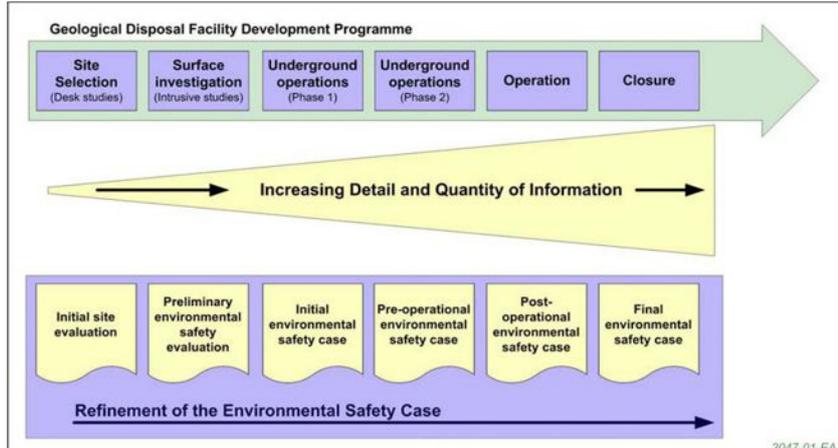
**Information needs and strategic objectives**  
 The Initial ESC will fulfil an important role in supporting the application for a variation to the environmental permit for a second phase of underground operations at a GDF. It will support the necessary environmental and planning applications to construct a GDF. The Initial ESC will also demonstrate to the regulators, stakeholders and others that RWM has confidence in the environmental safety of a GDF at a specific site.

The GRA [1] states that the Initial ESC will:  
 “...need to provide enough evidence to inform a decision on whether [the Environment Agency] can grant an authorisation for disposal in principle”.  
 If regulatory requirements are met the regulators will permit further underground operations, including construction of waste disposal areas and all required waste handling facilities (at the surface and underground).



*One of the challenges of the Initial ESC is to address potential impacts of future climate states, such as glaciation, on the GDF*

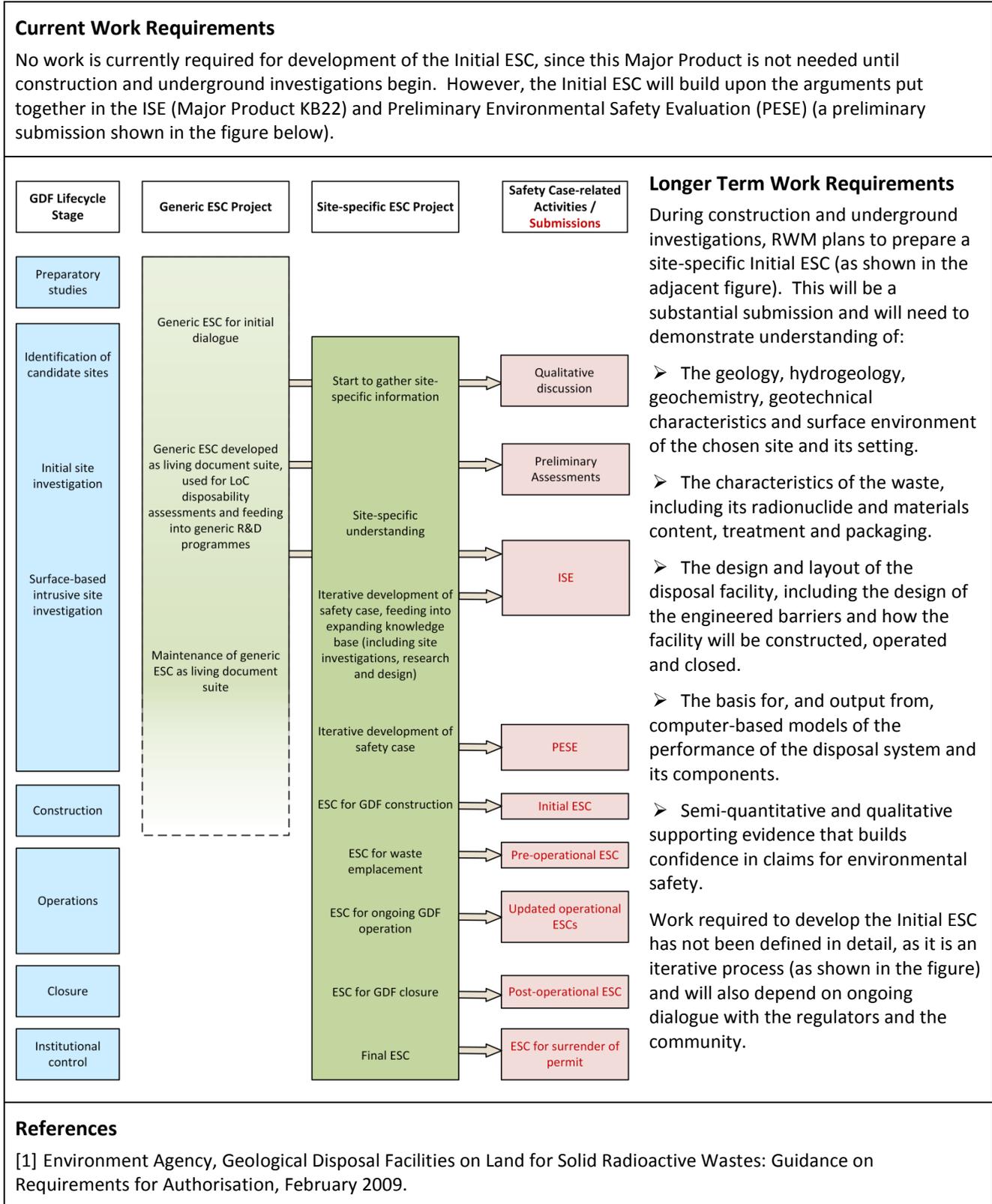
**Overview**  
 As progress is made in siting it is anticipated that, during underground operations, RWM will prepare an Initial Environmental Safety Case (ESC).  
 The Initial ESC is a site-specific ESC that will be prepared following the Initial Site Evaluation (ISE - Major Product KB22) and the Preliminary Environmental Safety Evaluation (PESE) that are required to start intrusive surface-based investigations and underground operations, respectively. This will therefore be the first in an expected series of site-specific environmental safety cases.  
 Although Major Products to be delivered during the underground investigations phase are not discussed in detail in this document, a brief description of the Initial ESC is provided here to illustrate the clear stepwise pathway for the development of the ESC over successive phases of the GDF implementation programme.



*This figure, extracted from the GRA, demonstrates how the ISE fits into the stepwise regulatory decision-making process, with the Initial ESC being further developed, in consultation with the regulators and local communities, throughout construction and underground investigations.*

Drivers					
Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development		Disposal System Design		Disposal System Specification	
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement		Transport Safety Case	
Waste Package Disposability					

# S&T Programme – Assessments Major Products



Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

## Generic Environmental Assessment (Major Product AS9)

Specification

### Purpose

- To support dialogue with RWM’s stakeholders (e.g. communities considering participation in the siting process) on the potential environmental effects of geological disposal.
- To inform development of RWM’s implementation plans for geological disposal, incorporating environmental mitigation and enhancement measures as appropriate.
- To build stakeholder confidence in RWM and in its proposals for implementing geological disposal.



*GDF construction will require the use of large plant and equipment*

Design

### Information needs and strategic objectives

This product supports RWM’s commitment to consider sustainability issues in implementing geological disposal and to engage with a wide range of stakeholders to maximise confidence in the programme. In particular it supports RWM’s strategic objective to engage with appropriate stakeholders to help create the conditions which could lead to the identification of a community, or communities, willing to participate in the process for siting a GDF.

Topics covered within the generic Environmental Assessment include:

- **Landscape and visual amenity** – including effects on the character and quality of the landscape, changes in views and effects on tranquillity.
- **Cultural heritage** – including effects on known and as yet undiscovered cultural heritage resources, the historic landscape and cultural values.
- **Geology and soils** – including effects on geological Sites of Special Scientific Interest (SSSIs) and mobilisation of any existing contaminants.
- **Water** – including effects of flood risk and impact of the facility on local flood risk, water quality, aquifer recharge and water supply.
- **Biodiversity, flora and fauna** – including habitat loss and disturbance of protected species.
- **Traffic and transport** – including effects associated with the transport of construction materials, rock spoil, staff and visitors, and radioactive waste packages.
- **Air** – including effects on levels of radioactive emissions and other pollutants to air and effects on UK air quality objectives.
- **Climate** – including the carbon footprint associated with a GDF and the effects of predicted climate change on GDF design development (e.g. changes in temperature, precipitation and sea level rise).
- **Noise & vibration** – including impacts of site investigation, construction, operation and closure in terms of transport and site-based activities.
- **Land-use** – including effects on land use arising from temporary and permanent land-take, and from disruption to existing land use management (e.g. agricultural use).
- **Waste** – including effects associated with the management of construction and operational wastes and consideration of the waste hierarchy.
- **Resource use, utilities and services** – focussing on the use of non-renewable resources.

### Overview

The Generic Environmental Assessment report [1] documents and presents the findings of RWM’s environmental assessment work. It takes the form of a concise main report, supported by detailed technical appendices.

The scope and content of the report is informed by the environmental issues raised by RWM’s stakeholders and which are likely to be raised by communities considering participation in the siting process for a GDF.

The report forms part of the suite of documents which together make up RWM’s generic Disposal System Safety Case. It has close links with the Generic Socio-economic Assessment and the Generic Health Impact Assessment.

Assessment

Underpinning Knowledge Base

## S&T Programme – Assessments Major Products

Drivers					
Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development	✓	Disposal System Design		Disposal System Specification	
Environmental Impact & Sustainability	✓	Environmental Safety Case		Flexibility in Decision Making	
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements		Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability					
<p><b>Current Work Requirements</b></p> <p>The Generic Environmental Assessment report [1] is currently being updated to reflect: recent changes to the radioactive waste inventory for disposal; RWM’s latest generic design work and implementation plans for the disposal system; Government policy on implementing geological disposal as set out in the 2014 White Paper: Implementing Geological Disposal [2].</p>					
<p><b>Longer Term Work Requirements</b></p> <p>No further development of this product is expected following the completion of transitional activities.</p>					
<p><b>References</b></p> <p>[1] RWM, <i>Geological Disposal: Generic Environmental Assessment</i>, NDA Technical Note 22926869, December 2014.</p> <p>[2] UK Department of Energy and Climate Change, <i>Implementing Geological Disposal – A Framework for the long-term management of higher activity radioactive waste</i>, URN 14D/235, July 2014.</p>					

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

## Generic Socio-economic Assessment (Major Product AS10)

Specification

### Purpose

- To support dialogue with RWM’s stakeholders (e.g. communities considering participation in the siting process) on the potential socio-economic effects of geological disposal.
- To inform development of RWM’s implementation plans for geological disposal, incorporating mitigation and enhancement measures as appropriate.
- To build stakeholder confidence in RWM and in its proposals for implementing geological disposal.



*Stakeholder engagement is an important part of the assessment of socio-economic impacts*

Design

### Information needs and strategic objectives

This product supports RWM’s commitment to consider sustainability issues in implementing geological disposal and to engage with a wide range of stakeholders to maximise confidence in the programme. In particular it supports RWM’s strategic objective to engage with appropriate stakeholders to help create the conditions which could lead to the identification of a community, or communities, willing to participate in the process for siting a GDF.

Topics covered within the generic Socio-economic Assessment include:

- **Employment** - including direct, indirect and induced employment effects.
- **Property values and blight** – covers potential effects during the siting process and during facility construction and operation.
- **Economic development** – covers potential effects on economic development at a District, regional and national level.
- **Tourism** – considers potential effects on both business and leisure tourism.
- **Agricultural sales** – includes an assessment of potential effects on the local agricultural economy and considers how to ensure adequate brand protection for agricultural produce
- **Social services and infrastructure** – considers potential effects on local social and public services – focussing on health and emergency services, leisure, sports and recreation facilities.
- **Social stability and community cohesion** – includes potential effects on people’s sense of belonging to a community and levels of satisfaction with community life.
- **Housing and accommodation** – covers potential housing and accommodation requirements associated with implementing a geological disposal facility and discusses possible accommodation strategies for workers
- **Distribution of socio-economic effects** – considers how socio-economic effects might be distributed across different segments of society.
- **Additional community investment** – considers how the Government’s commitment to additional, long term investment in a host community might contribute to the development of the community’s social and economic well-being and help it to achieve its development goals.

Assessment

### Overview

The Generic Socio-economic Assessment report [1] documents and presents the findings of RWM’s socio-economic assessment work. It takes the form of a concise main report, supported by detailed technical appendices.

The scope and content of the report is informed by the socio-economic issues raised by RWM’s stakeholders and which are likely to be raised by communities considering participation in the siting process for a GDF.

The report forms part of the suite of documents which together make up RWM’s generic Disposal System Safety Case. It has close links with the Generic Environmental Assessment and the Generic Health Impact Assessment.

Underpinning Knowledge Base

## S&T Programme – Assessments Major Products

Drivers				
Commercial / Contractual		Cost Impacts		Design Codes & Standards
Disposal Concept Development		Disposal System Design		Disposal System Specification
Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making
NDA Strategy		Operational Safety Case		Programme / Risk Management
QA / Data Robustness		Regulatory Requirements		Safety Case Methodology
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)
Socioeconomic Impacts	✓	Stakeholder Engagement	✓	Transport Safety Case
Waste Package Disposability				
<p><b>Current Work Requirements</b></p> <p>The Generic Socio-economic Assessment report [1] is currently being updated to reflect: recent changes to the radioactive waste inventory for disposal; RWM's latest generic design work and implementation plans for the disposal system; Government policy on implementing geological disposal as set out in the 2014 White Paper: Implementing Geological Disposal [2].</p>				
<p><b>Longer Term Work Requirements</b></p> <p>No further development of this product is expected following the completion of transitional activities.</p>				
<p><b>References</b></p> <p>[1] RWM, <i>Geological Disposal: Generic Socio-economic Assessment</i>, NDA Technical Note 22928394, December 2014.</p> <p>[2] UK Department of Energy and Climate Change, <i>Implementing Geological Disposal – A Framework for the long-term management of higher activity radioactive waste</i>, URN 14D/235, July 2014.</p>				

Specification

Design

Assessment

Underpinning Knowledge Base

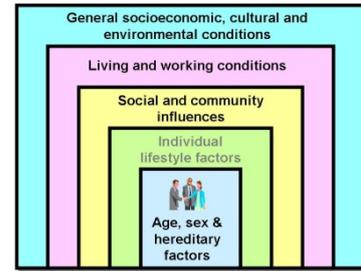
# S&T Programme – Assessments Major Products

## Generic Health Impact Assessment (Major Product AS11)

Specification

### Purpose

- To support dialogue with RWM’s stakeholders (e.g. communities considering participation in the siting process) on the potential effects of geological disposal on health and well-being.
- To inform development of RWM’s implementation plans for geological disposal, incorporating mitigation and enhancement measures as appropriate.
- To build stakeholder confidence in RWM and in its proposals for implementing geological disposal.



*A variety of social, economic, environmental and cultural factors affect health (sometimes referred to as ‘determinants of health’), and are considered in Health Impact Assessment*

Design

### Information needs and strategic objectives

This product supports RWM’s commitment to consider sustainability issues in implementing geological disposal and to engage with a wide range of stakeholders to maximise confidence in the programme. In particular it supports RWM’s strategic objective to engage with stakeholders to help create the conditions which could lead to the identification of a community, or communities, willing to participate in the process for siting a GDF.

Topics covered by the generic Health Impact Assessment include:

- **Recreation, amenity and physical activity** – considers how development of a GDF could affect levels of physical activity in the local community.
- **Transport and health** – includes potential health effects associated with transport movements to and from a GDF; considers how the project could promote more sustainable modes of travel for workers (e.g. cycling and walking) and how improvements to the local transport network could improve accessibility to local services, reduce congestion and improve road safety.
- **Access to services and facilities** – considers how to ensure important local services and facilities (e.g. schools, community centres and healthcare facilities) remain accessible, effective and able to cope with any increased demand as a result of GDF development.
- **Community cohesion and health** – considers potential effects on community cohesion and related health and well-being effects linked to levels of happiness, the provision of effective social health and support networks, levels of stress / anxiety, fear of crime and actual crime.
- **Radiological safety** – explains how observable health effects from very low additional radiation doses are extremely unlikely. Also considers potential health effects related to fear of radiation and associated levels of anxiety and how these might be mitigated.
- **Environmental effects and health** – assesses how environmental effects such as noise nuisance and dust generation might affect health and what measures might be deployed to avoid any adverse effects.
- **Socio-economic effects and health** – discusses the links between socio-economic factors (e.g. income and living standards) and health
- **Effects on potentially sensitive social groups** – considers how potential effects on health and well-being might be experienced by different social groups – particularly those which may be more sensitive to change as a consequence of characteristics such as age, disability or socio-economic status.

### Overview

The Generic Health Impact Assessment report [1] documents and presents the findings of RWM’s assessment of the potential effects of geological disposal on health and well-being. It takes the form of a concise main report, supported by detailed technical appendices.

The scope and content of the report is informed by the health and well-being issues raised by RWM’s stakeholders and which are likely to be raised by communities considering participation in the siting process for a GDF.

The report forms part of the suite of documents which together make up RWM’s generic Disposal System Safety Case. It has close links with the Generic Environmental Assessment and the Generic Socio-economic Assessment.

Assessment

Underpinning Knowledge Base

## S&T Programme – Assessments Major Products

Drivers				
Commercial / Contractual		Cost Impacts		Design Codes & Standards
Disposal Concept Development		Disposal System Design		Disposal System Specification
Environmental Impact & Sustainability	✓	Environmental Safety Case		Flexibility in Decision Making
NDA Strategy		Operational Safety Case		Programme / Risk Management
QA / Data Robustness		Regulatory Requirements		Safety Case Methodology
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)
Socioeconomic Impacts	✓	Stakeholder Engagement	✓	Transport Safety Case
Waste Package Disposability				
<p><b>Current Work Requirements</b></p> <p>The Generic Health Impact Assessment report [1] is currently being updated to reflect: recent changes to the radioactive waste inventory for disposal; RWM’s latest generic design work and implementation plans for the disposal system; Government policy on implementing geological disposal as set out in the 2014 White Paper: Implementing Geological Disposal [2].</p>				
<p><b>Longer Term Work Requirements</b></p> <p>No further development of this product is expected following the completion of transitional activities.</p>				
<p><b>References</b></p> <p>[1] RWM, <i>Geological Disposal: Generic Health Impact Assessment</i>, NDA Technical Note 22931162, December 2014.</p> <p>[2] UK Department of Energy and Climate Change, <i>Implementing Geological Disposal – A Framework for the long-term management of higher activity radioactive waste</i>, URN 14D/235, July 2014.</p>				

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

## Community-specific Assessments (Major Product AS12)

Specification

### Purpose

- To support dialogue, particularly with communities participating in the siting process, on the potential effects of geological disposal.
- To support the selection of sites for intrusive surface-based investigations.
- To inform development of RWM’s implementation plans for geological disposal in the context of specific communities, incorporating mitigation and enhancement measures as appropriate.
- To build stakeholder confidence in RWM and in its proposals for implementing geological disposal.



*Interaction with the public during the earlier MRWS process*

### Overview

Community-specific assessments are likely to be undertaken for each community constructively engaged in the siting process.

The scope and content of the assessments will be informed by the issues raised by these communities and by RWM’s other key stakeholders.

The scope and content of RWM’s generic assessment work (see Major Products AS9, AS10 and AS11) provides an indication of the likely coverage of the community-specific assessment work.

Design

### Information needs and strategic objectives

This product will support one of RWM’s key activities: to implement Government policy on geological disposal of Higher Activity Waste. In particular, it will support dialogue with communities participating in the siting process, and will help RWM to focus on communities > areas > potential sites where we can be reasonably confident of obtaining development consent and community consent for a Geological Disposal Facility. Ultimately, the community-specific assessments will inform the selection of a site (or sites) for intrusive, surface-based investigations. They will complement RWM’s preliminary safety assessment work.

The scope and content of community-specific assessments has yet to be determined and may vary by community. However, the assessment topics covered by the Generic Environmental, Socio-economic and Health Impact Assessments provide an indication of likely coverage.

Assessment

### Drivers

Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development		Disposal System Design		Disposal System Specification	
Environmental Impact & Sustainability	✓	Environmental Safety Case		Flexibility in Decision Making	
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements		Safety Case Methodology	
Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts	✓	Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability					

### Current Work Requirements

No current work requirements.

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

<p><b>Longer Term Work Requirements</b></p> <p>Longer term work requirements will be determined by the site selection framework (Major Product AS17) and through dialogue with those communities constructively engaged in the siting process.</p> <p>Site-specific assessments will be required to support Development Consent Applications for intrusive surface-based investigations (i.e. boreholes) at specific sites. The site-specific assessments will complement RWM’s preliminary safety assessment work and Initial Site Evaluation being undertaken to support Environmental Permit applications.</p> <p>RWM’s site-specific assessment work will comply with the relevant statutory requirements pertaining to Development Consent applications (see [1], [2], [3]) Each application is likely to include development and publication of the following Major Products:</p> <ul style="list-style-type: none"> <li>➤ Environmental Impact Assessment (EIA) scoping report.</li> <li>➤ Preliminary Environmental Information (PEI).</li> <li>➤ Environmental Statement.</li> <li>➤ Habitats Regulations Assessment (HRA) Evidence Plan.</li> <li>➤ Habitats Regulations Assessment (HRA) Report.</li> </ul> <p>A number of other Major Products will be required to support Development Consent applications and these will be covered by the Siting Work Area (see Major Products AS16 to AS20).</p>	Specification
<p><b>References</b></p> <p>[1] <i>The Infrastructure Planning (Environmental Impact Assessment) Regulations 2009</i>, SI 2009/2263 (as amended).</p> <p>[2] <i>The Conservation of Habitats and Species Regulations 2010</i>, SI 2010/490 (as amended).</p>	Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

## Disposability Assessments (Major Product AS13)

Specification

### Purpose

To assess the suitability of proposals for conditioning higher activity radioactive wastes for future disposal, leading to advice for operators processing and packaging radioactive wastes.

### Information needs and strategic objectives

Preparation of disposability assessments addresses the following objective:

*“In conjunction with waste producers identify and deliver solutions to optimise the management of higher activity wastes”.*

The associated RWM strategic activity is:

*“To work with waste producers to develop optimal packaging solutions for higher activity wastes”.*

The disposability assessment process represents consideration of the anticipated performance of proposed waste packages against the required waste package safety functions. In most cases, the assessment either confirms that the requisite safety function performance is provided (in which case, a LoC may be awarded (Major Product AS14), or leads to development work so that the necessary underpinning is provided. In other cases, it leads RWM to develop its design or safety case. The Major Product here comprises a suite of disposability assessment reports that continues to grow as new assessments are completed.

During the production of the generic Disposal System Specification (DSS) and the generic Disposal System Safety Case (DSSC), RWM developed an approach which defined safety functions for each of the various components of the multiple barrier system, including those provided by the waste package. The generic packaging specifications (see Major Product AS15) define those waste package properties commensurate with achieving the required waste package safety functions and compliance with the DSS.

The Major Product from each disposability assessment (i.e. the assessment report) provides confidence that the DSS and DSSC are congruent with ‘real’ waste packages. The process explicitly includes a requirement to identify technical queries relating to waste packaging proposals which may need to be addressed as part of the ongoing development of the DSS / DSSC. Such queries are recorded in the packaging assessment team database (sometimes referred to as the “PATdb”), and reviewed on no less than an annual basis to ensure that appropriate action is being taken; this may include the planning / provision of appropriate research and development, as identified in RWM’s S&T Plan (Major Product KB2).

Disposability assessments tend to contain commercial information and are therefore not generally published in full. However, each time a disposability assessment report is issued, RWM produces a summary of the key points and conclusions, which is published on the NDA website.



**Fuels for potential new nuclear power stations require disposability assessments**

### Overview

The disposability assessment process allows RWM to consider waste packaging proposals submitted by waste producers to RWM for:

- Compliance with RWM packaging specifications.
- Consistency with the generic DSSC.

There are several potential stages of interaction with waste producers on packaging proposals:

- Pre-conceptual stage – when a waste producer is considering different options for retrievals and packaging.
- Conceptual stage – initial consideration of a proposed packaging concept.
- Interim stage – development of the concept and packaging facility.
- Final stage – licensing of the packaging facility.
- Periodic review – maintenance of the final stage Letter of Compliance (LoC) to ensure that it remains consistent with the DSSC as disposal concepts evolve.

Progression between assessment stages must be accompanied by closure of relevant action points.

Design

Assessment

Underpinning Knowledge Base

### Drivers

Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development		Disposal System Design		Disposal System Specification	
Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making	

# S&T Programme – Assessments Major Products

NDA Strategy	✓	Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement		Transport Safety Case	
Waste Package Disposability	✓				

Specification

Design

Assessment

Underpinning Knowledge Base

**Notes:**

(1) The disposability assessment process is an important risk management tool for waste producers, giving confidence that the risk of inappropriate treatment and subsequent non-compliance with transport and disposal acceptance criteria has been minimised. Joint regulatory guidance on the management of higher activity wastes [1] identifies the RWM disposability assessment report as a potential input into the waste producer’s ‘Radioactive Waste Management Case’.

(2) Scottish Government Policy is that the long-term management of higher activity radioactive waste arising in Scotland should be in near-surface facilities. Such facilities should be located as near as possible to the site where the waste is produced [2]. The assessment basis for RWM’s advice on, and endorsement of, packaging proposals for wastes arising in Scotland is the geological disposal system safety case, because the view (supported by regulators) is that packages conditioned in anticipation of geological disposal will also be suitable for long-term storage. This advice is provided through the disposability assessment process [3].

(3) The disposability assessment process may also be deployed in support of the Health and Safety Executive’s Generic Design Assessment process for new nuclear build proposals or in support of strategic options studies commissioned by NDA. The disposability assessment process is supported by quality assurance audits.

**Current Work Requirements**

Disposability assessments are undertaken under contract by RWM for waste owners. Each disposability assessment is treated as a separate project and evaluates disposability in the following areas:

***Nature and Quantities of waste evaluation and preparation of waste package data summary sheets***

A description of the origins, composition and quantity of the waste proposed to be packaged, describing the expected range of waste package composition resulting from the proposed packaging process. It therefore provides the key defining input to the overall disposability assessment process.

***Wasteform properties evaluation***

A description of the range of composition and anticipated properties of the proposed wasteform resulting from any treatment and conditioning, and its potential evolution, including the potential for gas evolution within the waste package and recommendations for gas generation rates for use in safety assessments.

***Container design evaluation***

A description of the proposed waste container design and material specifications, and an assessment of whether the proposed waste containers are consistent with the requirements defined by the relevant packaging specification.

***Container integrity evaluation***

A description of the proposed waste container and its likely internal environment, together with corrosion-related properties of waste container materials and potential effects of wasteform interaction and evolution.

***Impact accident performance evaluation***

Identification of the anticipated performance of the waste package under impact accident conditions. It results in a recommended particulate release fraction, based upon impact accident scenarios defined by the relevant packaging specification, for use in safety assessments.

***Fire accident performance evaluation***

Identification of the anticipated performance of the waste package under fire accident conditions. It results in recommended radionuclide release fractions, based upon the fire accident scenarios defined by the relevant packaging specification, for use in safety assessments.

# S&T Programme – Assessments Major Products

Specification

**Data recording evaluation**

Assessment of whether waste producers have designed a suitable system for waste package data acquisition, recording and retention in support of all future stages of the long-term management of waste packages.

**Quality management system (QMS) evaluation**

Assessment of whether waste producers are working within a suitable QMS. It also establishes whether waste producers are controlling all activities that can affect the properties and performance of waste packages.

**Policy evaluation**

A critical analysis of the information available in the context of the disposability assessment aim and principles.

**Concept compatibility evaluation**

Evaluation of whether the proposed waste packages (and any proposed transport system) are consistent with the generic disposal system designs and packaging specification. The concept compatibility evaluation may also be used as a vehicle to undertake an evaluation of cost, footprint and lifetime impacts of the generic disposal system.

Design

**Criticality evaluation**

This evaluation defines a justifiable safe fissile mass for proposed waste packages consistent with the criticality safety requirements of the relevant packaging specification.

**Transport safety assessment**

An assessment of whether the waste package in its transport package configuration will comply with the generic Transport Safety Case and hence provide the specified safety functions that will ensure safe transport to the GDF.

**Operational safety assessment**

A determination of whether the waste package characteristics and predicted performance will be compliant with the generic Operational Safety Case, including assessment of whether the expected fissile material content, toxic/hazardous materials and heat output of the proposed waste packages are consistent with requirements.

Assessment

**Post-closure performance assessment**

A determination of whether the waste package characteristics and predicted long-term performance will be compliant with the generic PCSA and hence provide the expected post-closure safety functions.

**Physical protection and safeguards evaluations**

Evaluations of whether the physical protection requirements for proposed waste packages are consistent with regulatory requirements. It also ensures that arrangements are in place to ensure effective nuclear materials accountancy during the retrieval and packaging of waste containing nuclear materials and that such information is suitable for transmission to a future GDF operator.

**Non-radiological environmental protection evaluation**

A critical analysis of the non-radiological environmental aspects, assessing whether there are any aspects of the packaging proposal that are inconsistent with wider environmental protection considerations.

Underpinning Knowledge Base

**Longer Term Work Requirements**

Preparation of assessment reports will continue throughout the development and construction of the GDF to meet the demands of waste producers and to reflect ongoing development of the DSS / DSSC.

**References**

- [1] HSE, Environment Agency and SEPA, *The Management of Higher Activity Radioactive Waste on Nuclear Licensed Sites. Part 2: Radioactive waste management cases*, February 2010.
- [2] Scottish Government, *Scotland’s Higher Activity Radioactive Waste Policy 2011*, January 2011.
- [3] NDA, *RWM Disposability Assessment Aim and Principles*, Doc. No. RWP60, Revision 2, March 2013.

# S&T Programme – Assessments Major Products

## Letters of Compliance (LoCs) (Major Product AS14)

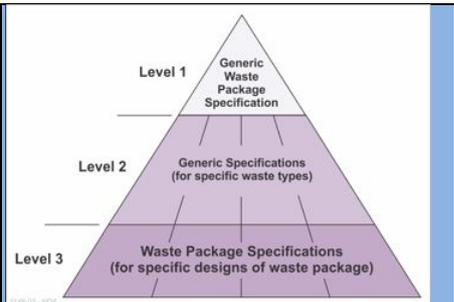
<p><b>Purpose</b></p> <p>The purpose of a LoC is to provide confidence to SLCs that they can progress with waste conditioning and packaging in the knowledge that they have taken appropriate steps to minimise the risk that waste packages thus manufactured would be unsuitable for transport and geological disposal.</p>	 <p><i>The 3m<sup>3</sup> concrete box is one of RWM's approved waste packages</i></p>	<p><b>Information needs and strategic objectives</b></p> <p>LoCs provide a record of those waste streams and associated waste packages that have been endorsed by RWM as suitable for transport to, and disposal in the GDF. As such, LoCs inform the design basis of the GDF as embodied in the Disposal System Specification and Safety Case.</p> <p>The RWM objective addressed by preparation of LoCs is:</p> <p><i>“In conjunction with waste producers identify and deliver solutions to optimise the management of higher activity wastes.”</i></p> <p>The associated RWM strategic activity is:</p> <p><i>“To work with waste producers to develop optimal packaging solutions for higher activity wastes.”</i></p> <p>The following information is recorded within the scope of the LoC:</p> <ul style="list-style-type: none"> <li>• A description of the waste, conditioning process and proposed waste container.</li> <li>• The scope of endorsement, including:                     <ul style="list-style-type: none"> <li>○ Waste stream(s), e.g. UKRWI waste stream identifier(s).</li> </ul> </li> <li>• Qualifications, in the form of exclusions, conditions and caveats. These qualifications are defined as follows [1]:                     <ul style="list-style-type: none"> <li>○ A <i>caveated</i> LoC; where there is uncertainty as to whether an issue may arise during packaging, which may result in a need for remedial action during or after the manufacture of waste packages.</li> <li>○ A <i>conditional</i> LoC; where further evidence is required regarding the proposed packaging process, which may have to be obtained during active commissioning of the packaging plan.</li> <li>○ A LoC with <i>exclusions</i>; where specified components of the waste stream are excluded from the endorsement.</li> </ul> </li> </ul> <p>LoCs are enduring documents in that they do not carry an expiry date. Their validity will be reviewed periodically with a view to renewing the endorsement against ‘current’ safety cases. The intention is that when a GDF is available, no LoC is more than 10 years old.</p>	<p><b>Overview</b></p> <p>Issue of a LoC confirms that a proposed waste package has been found to be compliant with packaging specifications and the geological disposal concept as defined in published generic design, safety and environmental assessments.</p> <p>There are several potential stages of LoC, each based upon stages of interaction with waste producers on packaging proposals:</p> <ul style="list-style-type: none"> <li>• Conceptual stage - initial consideration of the packaging concept.</li> <li>• Interim stage - development of the concept and packaging facility.</li> <li>• Final stage - licensing of the packaging facility.</li> </ul> <p>Waste packaging proposals may be endorsed by issue of a LoC following satisfactory completion of a disposability assessment (see Major Product AS13) at the relevant stage of interactions and provided that any relevant action points have been closed. The Major Product here comprises the various LoCs issued by RWM to waste producers, which are continually added to as new packaging proposals are endorsed.</p>	Specification																					
<p><b>Drivers</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Commercial / Contractual</td> <td style="width: 10%;"></td> <td style="width: 33%;">Cost Impacts</td> <td style="width: 10%;"></td> <td style="width: 14%;">Design Codes &amp; Standards</td> <td style="width: 10%;"></td> </tr> <tr> <td>Disposal Concept Development</td> <td></td> <td>Disposal System Design</td> <td></td> <td>Disposal System Specification</td> <td></td> </tr> <tr> <td>Environmental Impact &amp; Sustainability</td> <td></td> <td>Environmental Safety Case</td> <td></td> <td>Flexibility in Decision Making</td> <td></td> </tr> <tr> <td>NDA Strategy</td> <td style="text-align: center;">✓</td> <td>Operational Safety Case</td> <td></td> <td>Programme / Risk Management</td> <td></td> </tr> </table>				Commercial / Contractual		Cost Impacts		Design Codes & Standards		Disposal Concept Development		Disposal System Design		Disposal System Specification		Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making		NDA Strategy	✓	Operational Safety Case	
Commercial / Contractual		Cost Impacts		Design Codes & Standards																					
Disposal Concept Development		Disposal System Design		Disposal System Specification																					
Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making																					
NDA Strategy	✓	Operational Safety Case		Programme / Risk Management																					
		Assessment																							
				Underpinning Knowledge Base																					

## S&T Programme – Assessments Major Products

Specification	QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
	Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)	
	Socioeconomic Impacts		Stakeholder Engagement		Transport Safety Case	
	Waste Package Disposability	✓				
Design	<p><b>Current Work Requirements</b></p> <p>Preparation of LoCs is generally undertaken as part of the close-out of the disposability assessment process (see Major Product AS13); it is essentially a formal record of close-out of all relevant action points against a particular stage of interaction for specific waste packaging proposals.</p>					
	<p><b>Longer Term Work Requirements</b></p> <p>Preparation of LoCs will continue throughout the development and construction of the GDF to meet the demands of waste producers and to reflect ongoing development of the Disposal System Specification and Safety Case.</p> <p>The need for formal endorsement of plans will be reviewed as Waste Acceptance Criteria for the GDF, and an associated acceptance process, are developed.</p>					
	<p><b>References</b></p> <p>[1] Pöyry, <i>An Explanation of the Differences between the 2007 Derived Inventory and the Equivalent Wastes and Materials in the 2010 UK Radioactive Waste Inventory</i>, 390761/23, 2011.</p>					
Assessment						
Underpinning Knowledge Base						

# S&T Programme – Assessments Major Products

## Generic Waste Package Specifications & Guidance Documentation (Major Product AS15)

<p><b>Purpose</b></p> <p>To define high-level generic requirements for waste packages containing all levels of higher-activity waste which will be subject to geological disposal.</p>	 <p><b>The hierarchy of RWM's Packaging Specifications</b></p> <p><b>Overview</b></p> <p>The RWM packaging specifications comprise a hierarchy of documents. Each level satisfies a specific function and is produced for a particular audience:</p> <ul style="list-style-type: none"> <li>• The Level 1 GWPS defines high-level requirements for all waste packages destined for disposal in a GDF. It is aimed at industry regulators and stakeholders not directly involved in the packaging of waste.</li> <li>• The Level 2 GWPS define generic requirements for all waste packages that will be disposed of in accordance with a specified concept or range of concepts. This encompasses packages containing wastes with similar radiological characteristics. They are produced for use by waste packagers involved in the development of new or innovative packaging proposals.</li> <li>• The Level 3 GWPS define, where applicable, quantitative requirements for waste packages containing a specific type of waste and using a standardised design of waste container, as identified by the DSTS. They are produced for use by waste packagers intending to use such a waste container for the packaging of waste.</li> </ul>	Specification					
<p><b>Information needs and strategic objectives</b></p> <p>The RWM objective addressed by preparation of the packaging specifications, and the supporting guidance is: <i>“In conjunction with waste producers identify and deliver solutions to optimise the management of higher activity wastes.”</i></p> <p>The associated RWM strategic activity is: <i>“To work with waste producers to develop optimal packaging solutions for higher activity wastes.”</i></p> <p>The packaging specifications Major Product comprises:</p> <ul style="list-style-type: none"> <li>➤ The production and maintenance of the RWM suite of packaging specifications for waste packages containing higher activity waste and other radioactive materials that may be subject to geological disposal.</li> <li>➤ The production of supporting guidance to assist in the interpretation and applications of the packaging specifications.</li> <li>➤ The development of a waste acceptance process for a GDF.</li> </ul> <p>Each Level 2 generic specification is based on a disposal concept (or range of concepts) for that type of waste and on the systems designs (i.e. for transport and the GDF itself) and safety assessments that derive from them. A further key input to a generic specification is the need for compliance with the regulatory environment under which the transport and disposal of the waste will take place. RWM packaging specifications also require that adequate controls shall be applied during any period of interim storage prior to the transfer of packaged waste to a GDF, to ensure that that the waste packages retain their required properties and performance for the duration of the storage period.</p> <p>The Level 3 Waste Package Specifications form part of the guidance documentation, which includes a range of specifications related to the packaging of waste (e.g. quality management, information recording) and supporting guidance. The guidance provided for the Level 3 WPS addresses a wide range of issues related to the actual packaging of waste, including any controls that are necessary on properties of the waste (e.g. controls on gas generation, the presence of void spaces and free liquids) that could otherwise deleteriously affect the performance of waste packages. The suite of guidance documentation includes ‘thematic’ guidance on a range of topics related to the packaging of waste and the disposability assessment process. Specific issues arising from the packaging of actual wastes with challenging characteristics (e.g. waste containing significant quantities of reactive metals such as uranium) can be the subject of targeted ‘thematic’ guidance. These issues are identified during dialogue with waste producers during the course of a disposability assessment or internally by RWM regarding future conditioning of a particular waste type.</p>			Design				
<p><b>Drivers</b></p> <table border="1" data-bbox="132 1928 1445 2018"> <tr> <td>Commercial / Contractual</td> <td>Cost Impacts</td> <td>Design Codes &amp; Standards</td> </tr> <tr> <td>Disposal Concept Development</td> <td>Disposal System Design</td> <td>Disposal System Specification</td> </tr> </table>				Commercial / Contractual	Cost Impacts	Design Codes & Standards	Disposal Concept Development
Commercial / Contractual	Cost Impacts	Design Codes & Standards					
Disposal Concept Development	Disposal System Design	Disposal System Specification					
Underpinning Knowledge Base							

## S&T Programme – Assessments Major Products

Specification	NDA Strategy		Operational Safety Case		Programme / Risk Management	
	QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
	Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)	
	Socioeconomic Impacts		Stakeholder Engagement		Transport Safety Case	
	Waste Package Disposability	✓				
<p><b>Notes:</b> Whilst not strictly part of the packaging specifications, RWM also produces standard waste package descriptions (SWPDs), which define quantitative requirements for specific designs of waste package containing a defined type of waste (i.e. with specified physical, chemical and nuclear properties), conditioned using a specified process in a specific design of waste container. Each SWPD is based on a design of waste package which has been endorsed by receipt of a final stage Letter of Compliance.</p>						
Design	<p><b>Current Work Requirements</b></p> <p>The basic approach to the production of a generic specification is the review of all relevant documentation to ensure that the standards and specifications are defined in such a manner that waste packages produced to be consistent with them will therefore be compliant with:</p> <ul style="list-style-type: none"> <li>➤ The required waste package safety functions, as identified by the Level 1 GWPS.</li> <li>➤ The physical constraints of the transport and GDF systems.</li> <li>➤ The regulations that apply to the transport, storage and disposal of the waste.</li> </ul> <p>The preparation of packaging specifications results in the progressive production and updating of documentation in the light of a wide range of inputs, including:</p> <ul style="list-style-type: none"> <li>➤ Broadening of the range of higher activity waste and other radioactive materials that may be considered for geological disposal.</li> <li>➤ Development of, and changes to, disposal concepts.</li> <li>➤ Updates of the Disposal System Specification and Safety Case.</li> <li>➤ Changes to regulatory arrangements.</li> <li>➤ Updates of inventory information.</li> <li>➤ Improvements in the knowledge base as a result of research work.</li> </ul>					
	<p>The aim of each Level 2 GWPS is to define standards and performance criteria for all waste packages containing a particular type of waste. In general this will not include a definition of specific waste package types, this being the purpose of the individual Level 3 WPS, which apply the bounding requirements defined by the Level 2 generic specifications to the waste packages manufactured using standardised designs of waste container. These latter documents form part of the WPSGD, which are produced in such a manner as to be useful to ‘users’ (i.e. those with the direct responsibility for packaging waste), as distinct from the generic specifications which are aimed at a wider range of stakeholders, most particularly the industry regulators.</p>					
Assessment	<p><b>Longer Term Work Requirements</b></p> <p>Ultimately all waste packages will be subject to an ‘acceptance process’ before they can be transported to and disposed of in a GDF. Such a process could have similarities with the existing disposability assessment process but it will apply to actual, rather than proposed waste packages and it will involve demonstrating compliance with the waste acceptance criteria (WAC) of an operational GDF rather than with the generic packaging specifications defined on the basis of a concept for a GDF. As the generic packaging specifications are expected to ‘evolve’ into WAC so the existing disposability assessment process will similarly evolve to an acceptance process and there are clear benefits for this evolution to commence in the short term. Some preparatory work has been done, by way of the definition of SWPDs based on the outcomes of the historic disposability assessments, and against which the acceptability of waste packages for transport and disposal can be assessed.</p> <p>Preparation of packaging specifications will continue throughout siting and construction in order to meet the needs of waste producers and reflect development of the Disposal System Specification and Safety Case.</p>					
	<p><b>Underpinning Knowledge Base</b></p>					

# S&T Programme – Assessments Major Products

## National Geological Screening Reports (Major Product AS16)

**Purpose**  
 The objective of National Geological Screening is to provide authoritative information that can be used in discussions with communities and may help RWM focus its engagement activities.

**Information needs and strategic objectives**

The framework for implementing geological disposal is set out in a White Paper published in 2014 [1]. The White Paper sets out a programme of work to be completed before formal discussions with communities can begin. National geological screening is included in this programme.

Development of the 2014 White Paper was informed by extensive consultation on the siting process for a GDF. Inputs to this consultation revealed a strong desire for early consideration of geology as a crucial step in building public understanding of GDF development, and confidence in the process to identify safe siting areas. As a result RWM was asked to carry out national geological screening based on the requirements of the existing generic GDF safety cases.

Two other areas of initial work were identified in the 2014 White Paper and are being completed by the Department of Energy and Climate Change. One relates to working with communities, which is addressing matters of community representation, community investment and testing of community support; and the other relates to land-use planning, which will establish both the GDF and the associated characterisation boreholes as Nationally Significant Infrastructure Projects, and designate a National Policy Statement in respect of these in England.

The siting process will commence when this initial programme of work has been completed.

The RWM objectives that national geological screening addresses are to “Engage with national and local governments and communities to identify a geological disposal facility site” and to “Obtain and maintain stakeholder support for our activities”.



**National geological screening Guidance will be applied across England, Wales and Northern Ireland to produce a series of narratives describing key characteristics of regional geological environments and their relevance to safety**

**Overview**

National geological screening is an exercise to bring together existing information about aspects of geology that are relevant to the long-term safety of a GDF and make it available in an accessible form. It will provide authoritative information for England, Wales and Northern Ireland that can be used in discussions with communities about their geological potential to host a GDF.

There are 2 parts to the exercise, the first part involves developing Guidance which sets out how the information will be assembled and presented. The second part involves applying the Guidance to produce outputs in the form of narratives and maps.

**Drivers**

Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development		Disposal System Design		Disposal System Specification	
Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making	
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements		Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability					

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

Specification

## Current Work Requirements

The national geological screening Guidance comprises:

- The safety requirements to which the geological environment contributes.
- Geological attributes that are relevant to meeting these safety requirements.
- Sources of existing geological information relevant to understanding these attributes.
- A description of the outputs that will be produced based on this existing geological information.

RWM worked with geoscientists and potential users of the information to develop the proposed Guidance. The White Paper set out that the Guidance would be reviewed by an Independent Review Panel and the resulting Guidance would be subject to public consultation before being finalised. At the time of writing, a public consultation on the Guidance is currently taking place; this will run until 4 December 2015.

Design

During 2016 the Guidance will be applied – across England, Wales and Northern Ireland – using the specialist expertise of the British Geological Survey, which holds much of the definitive existing information on British geology and has access to many other data sources. The Independent Review Panel will also be asked to assess the application of the guidance.

The outputs of screening are proposed to be a series of brief narratives describing the key characteristics of the geological environment of the region and their relevance to safety. The narratives will be illustrated with maps where appropriate. Packages of outputs will be produced for each geological region of England, Wales and Northern Ireland. The geological regions will be those used by the British Geological Survey in its Regional Guides. The Regional Guide publication series provides a structure for which there is a well-established source of more detailed information for those who would like to know more.

Assessment

## Longer Term Work Requirements

Collectively the programme of work identified in the 2014 White Paper will provide answers to questions that communities may raise as they consider whether to become involved in the GDF siting process. By having answers to fundamental questions on topics such as community representation and investment, safety, geology, and land-use planning, early discussions should be more productive and therefore increase the possibility that communities may wish to find out more about the siting process.

The siting process will commence when the initial programme of work has been completed. It will involve engagement with communities to identify and assess potential sites over a number of years. Initial discussions may relate to identifying detailed sources of geological information relevant to community areas and information relevant to the surface environment. RWM will work with communities to identify potential sites and assess their suitability.

## References

[1] UK Department of Energy and Climate Change, *Implementing Geological Disposal – A Framework for the long-term management of higher activity radioactive waste*, URN 14D/235, July 2014.

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

## Site Selection Framework (Major Product AS17)

### Purpose

- To provide a framework for developing detailed approaches to site identification, evaluation and selection at appropriate points in the siting process.
- To support early dialogue with communities considering participation in the siting process.
- To build stakeholder confidence in RWM and in its proposals for implementing geological disposal.

### Information needs and strategic objectives

The 2014 White Paper [1] identifies Radioactive Waste Management Limited as being responsible for implementing Government policy on geological disposal. It also states that Government continues to favour an approach to siting a geological disposal facility based on working with communities that are willing to participate in the process. Following the completion of a number of initial actions outlined in the White Paper, formal engagement with interested communities is currently expected to begin in 2017.

In preparation for formal engagement, RWM is developing a framework for site identification, evaluation and selection. This will set out approaches, associated methods and tools that can be used to:

- Narrow down the focus of RWM’s work from a community (or communities), to areas, to potential sites for intrusive, surface-based investigations (i.e. boreholes).
- Support a decision on which of these sites to take forward for intrusive, surface-based investigations.
- Support a decision on a preferred site, following the completion of intrusive, surface-based investigations and the evaluation of detailed site characterisation data.

At this early stage it is not possible to develop a detailed approach for the whole siting process. However, a range of possible approaches is being developed with a particular focus on the initial task of identifying potential sites for intrusive, surface-based investigations. The work is being guided by a number of key principles:

- Approaches will be informed, but not constrained, by international experience and previously published approaches for the staged Managing Radioactive Waste Safely (MRWS) process.
- Approaches will be flexible so that they can be easily adapted to different communities.
- Approaches will be collaborative and transparent, involving RWM, participating communities as appropriate and other key stakeholders working together to agree and then implement the siting process.
- Approaches will be simple and robust, so that the reasons for selecting candidate communities/sites (and ultimately the preferred site) are clear, easy to understand and to justify.
- A clear audit trail for decision making will need to be evident from the initial focussing work through to the selection of a preferred site.



*Planning and development of the site selection framework is ongoing and will involve engagement with interested communities when the siting process begins*

### Overview

The site selection framework will:

- Set out possible approaches, methods and tools that can be used for narrowing down the focus of RWM’s site identification work from a community (or communities), to areas, to potential sites for intrusive, surface-based investigations.
- Outline approaches to the evaluation of these potential sites - to support a decision on which to take forward for intrusive, surface-based investigations.
- Outline possible approaches to detailed site assessment - to support the selection of a preferred site for the construction and operation of a GDF.

The site selection framework will provide a basis for more detailed development of these approaches and associated deliverables at appropriate points during the siting process. This more detailed work will be undertaken in collaboration with participating communities and other key stakeholders as appropriate.

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

Specification

The framework is likely to include proposals for “focussing criteria”, developed around topic areas such as safety, environmental effects, transport infrastructure and community interests. It is also likely to include proposals for “evaluation criteria” to support a decision on which sites to take forward for intrusive, surface-based investigations. In both cases it is anticipated that such criteria will be further developed and finalised with input from participating communities and other key stakeholders, as appropriate, during the siting process.

**Drivers**

Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development		Disposal System Design		Disposal System Specification	
Environmental Impact & Sustainability	✓	Environmental Safety Case		Flexibility in Decision Making	
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements		Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results	✓	Siting Process (Voluntarism)	✓
Socioeconomic Impacts	✓	Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability					

Design

**Current Work Requirements**

The site selection framework is currently being developed in preparation for launch of the formal siting process in 2017.

**Longer Term Work Requirements**

Various aspects of the siting framework will be developed in more detail at appropriate points during the siting process, in collaboration with participating communities and other key stakeholders as appropriate. It is anticipated this work will include developing and publishing a number of reports which detail the approaches to and outcome of:

- Initial site identification early in the siting process.
- The evaluation of potential sites to support a decision on which to take forward for intrusive, surface-based investigations (i.e. boreholes).
- The assessment of sites subject to intrusive, surface-based investigations to support the selection of a preferred site.

Assessment

**References**

[1] UK Department of Energy and Climate Change, *Implementing Geological Disposal – A Framework for the long-term management of higher activity radioactive waste*, URN 14D/235, July 2014.

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

## Development Consent Application for Boreholes (Major Product AS18)

<p><b>Purpose</b></p> <ul style="list-style-type: none"> <li>• To secure development consent for borehole investigations to determine the suitability of a site for hosting a GDF.</li> <li>• To support community consultation on proposals for boreholes.</li> <li>• To build stakeholder confidence in RWM and in its proposals for implementing geological disposal.</li> </ul>	<p>The application process. The six steps</p> <p>The Inspectorate, on behalf of the Secretary of State, has 28 days to decide whether the application meets the required standards to proceed to examination including whether the developer's consultation has been adequate.</p> <p>You can send in your comments in writing. You can request to speak at a public hearing. The Inspectorate has 6 months to carry out the examination.</p> <p>There is the opportunity for legal challenge.</p> <p>Pre-application → Acceptance → Pre-examination → Examination → Decision → Post-decision</p> <p>Look out for information in local media and in public places near the location of the proposed project, such as your library. The developer will be developing their proposals and will consult widely.</p> <p>You can now register as an interested party; you will be kept informed of progress and opportunities to put your case. Inspectors will hold a Preliminary Meeting and set the timetable for examination.</p> <p>A recommendation to the relevant Secretary of State will be issued by the Inspectorate within 3 months. The Secretary of State then has a further 3 months to issue a decision on the proposal.</p>
<p><b>Information needs and strategic objectives</b></p> <p>The Infrastructure Planning (Radioactive Waste Geological Disposal Facilities) Order 2015 [1] brought radioactive waste geological disposal facilities and associated borehole investigations into the land-use planning regime for nationally significant infrastructure projects in England. Under this regime, applications for development consent are made to the Planning Inspectorate. Having examined an application, the Planning Inspectorate makes a recommendation to the relevant Secretary of State, who in turn makes a decision on whether to grant or to refuse development consent.</p> <p>Should circumstances arise requiring land-use planning decisions in Wales or Northern Ireland, then an application would be taken through the appropriate planning system. In all cases it is assumed that the process would involve similar approaches.</p> <p>Applications for an order granting development consent for borehole investigations must be made in the form set out in the Prescribed Forms and Procedures Regulations [2]. These set out the detailed procedures which must be followed for submitting and publicising applications. In particular, they detail the documents that must, where relevant, accompany an application. These include, but are not be limited to:</p> <ul style="list-style-type: none"> <li>➤ The draft proposed order, together with an explanatory memorandum which sets out the purpose and effect of the provisions in the order.</li> <li>➤ A statement of reasons, a funding statement and book of reference relating to any compulsory acquisition of land, or an interest in / right over land (see also Major Product AS20).</li> <li>➤ An Environmental Statement, together with any associated screening or scoping opinions (see also Major Product AS12).</li> <li>➤ A report, or reports, addressing the requirements of the Habitats Assessment Regulations (see also Major Product AS12).</li> <li>➤ A consultation report detailing the pre-application consultation process and responses received.</li> <li>➤ Various plans, drawings and documents describing the proposals (a project definition).</li> </ul> <p>The statutory development consent process will be initiated with a formal notification to the Planning Inspectorate that RWM intend to submit an application. There will then be a period of extensive consultation on the proposals, together with an iterative design and assessment process, before an application is submitted.</p>	<p><b>The current development consent application process proceeds through six steps: Pre-application, Acceptance, Pre-examination, Examination, Decision, and Post-decision</b></p> <p><b>Overview</b></p> <p>In March 2015 geological disposal facilities and associated borehole investigations were brought into the planning regime for nationally significant infrastructure projects.</p> <p>Under this regime, and for sites in England, RWM will have to submit a development consent application to the Planning Inspectorate for borehole investigations. For sites in Wales or Northern Ireland an application would have to be taken through an appropriate, equivalent process.</p> <p>An application will be required for each site under investigation – and possibly for each successive tranche of boreholes at a particular site.</p> <p>Each application will involve completion of an application form and a number of accompanying documents, some of which are described elsewhere in this report under Major Product AS12.</p>

Specification

Design

Assessment

Underpinning Knowledge Base

## S&T Programme – Assessments Major Products

Specification	<b>Drivers</b>				
	Commercial / Contractual		Cost Impacts		Design Codes & Standards
	Disposal Concept Development		Disposal System Design		Disposal System Specification
	Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making
	NDA Strategy	✓	Operational Safety Case		Programme / Risk Management
	QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology
	Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)
	Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case
		Waste Package Disposability			
Design	<b>Current Work Requirements</b>				
	Work is currently on-going to take account of the application process and supporting document production in RWM’s implementation plans.				
	<b>Longer Term Work Requirements</b>				
	Preparation of the application and supporting documents will commence during the transitional activities phase, with submission / publication early in the surface-based site investigations (enabling activities) phase.				
Assessment	<b>References</b>				
	[1] <i>The Infrastructure Planning (Radioactive Waste Geological Disposal Facilities) Order 2015</i> , SI 2015/949.				
	[2] <i>The Infrastructure Planning (Applications: Prescribed Forms and Procedures) Regulations 2009</i> , SI 2009/2264 (as amended).				
Underpinning Knowledge Base					

# S&T Programme – Assessments Major Products

## Property Value Protection Approach (Major Product AS19)

<p><b>Purpose</b></p> <p>To understand the potential effects that a GDF and the broader GDF siting process might have on property values or the perception thereof.</p>		Specification		
<p><b>Information needs and strategic objectives</b></p> <p>Various Property Value Protection (PVP) schemes have been implemented for different projects, and there are different ways in which they can be managed.</p> <p>The potential effect that a GDF and the broader GDF siting process might have on property values within the locality is likely to be an issue of concern to any community considering engaging in the GDF siting process. PVP schemes can provide confidence amongst members of a local community that compensation will be available should any demonstrable impacts on property value be encountered. Such agreements are recommended by the IAEA for mitigating potential impacts on the built environment of a facility host community [1].</p> <p>RWM’s work programme in this area aims to consider what the perceived or actual effects of a GDF might be on property values and to understand how other projects have chosen to address this issue. RWM will then need to decide whether it is appropriate to develop a PVP scheme for geological disposal and, if so, what the scope of that scheme would need to be.</p>			<p><i>Large infrastructure projects, such as development of the High Speed 2 (HS2) rail link and development of a GDF have the potential to affect property values</i></p> <p><b>Overview</b></p> <p>The potential effect that siting and constructing a GDF may have on actual or perceived property values is likely to become an issue that RWM will need to address. To mitigate any negative effects associated with implementation, Property Value Protection (PVP) schemes have been put in place for some of the UK Government’s Major Projects Portfolio, including HS2 and Hinkley Point C, and are standard practice for road construction.</p> <p>Requirements for a GDF PVP scheme are currently being evaluated by RWM.</p>	Design
<p><b>Current Work Requirements</b></p> <p>Current work aims to inform consideration of whether a PVP scheme needs to be developed and, if so, what its scope would need to be. This is currently being progressed by reviewing available information on the following topics:</p> <ul style="list-style-type: none"> <li>➤ Whether available evidence suggests that implementation of a GDF in England, Wales or Northern Ireland would likely have a significant (or perceived) effect on local property values and, if so, the spatial scale and magnitude of such effects.</li> <li>➤ The nature of PVP schemes that have been implemented in relation to other large infrastructure projects and radioactive waste management facilities in the UK and overseas.</li> <li>➤ The scope and scale of such schemes and how they have been managed.</li> </ul> <p>Outcomes from this review will inform RWM decision-making on whether a PVP scheme for geological disposal in the UK is required and, if so, will be used to plan the scope, development, implementation and management of a suitable PVP scheme.</p>				

Drivers				
Commercial / Contractual		Cost Impacts		Design Codes & Standards
Disposal Concept Development		Disposal System Design		Disposal System Specification
Environmental Impact & Sustainability	✓	Environmental Safety Case		Flexibility in Decision Making
NDA Strategy		Operational Safety Case		Programme / Risk Management
QA / Data Robustness		Regulatory Requirements		Safety Case Methodology
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)

Specification
  
  
Design
  
  
Assessment
  
  
Underpinning Knowledge Base

## S&T Programme – Assessments Major Products

Specification	Socioeconomic Impacts	✓	Stakeholder Engagement	✓	Transport Safety Case	
	Waste Package Disposability					
<p><b>Longer Term Work Requirements</b></p> <p>If a PVP scheme is determined to be required as a result of ongoing review work, such a scheme would be developed in consultation with potential host communities.</p>						
<p><b>References</b></p> <p>[1] International Atomic Energy Agency (2002). <i>Socio-economic and other non-radiological impacts of the near surface disposal of radioactive waste</i>. TECDOC 1308.</p>						

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Assessments Major Products

## Approach to Acquisition of Land & Mineral Rights (Major Product AS20)

<p><b>Purpose</b></p> <p>To support acquisition of the necessary temporary access rights and permanent rights in the land surrounding a potential site for a GDF to facilitate step-wise site investigations and, if appropriate in due course, to construct and operate a GDF.</p>					
<p><b>Information needs and strategic objectives</b></p> <p>A necessary part of planning for land acquisition will be to investigate and understand ownership of land (and the sub-surface) before committing to acquire, or acquire an interest in, that land. The ownership of land carries risk (for example, the land might be subject to additional charges or obligations) and these risks need to be understood and, if necessary, mitigated prior to taking ownership of the land. In addition, assessing whether acquiring land rights is achievable (i.e. successfully identifying and understanding the ownership and any associated issues with regards to any third party) is key to determining whether to proceed with a GDF at any potential site.</p> <p>With regards to the land below the surface (which includes mineral rights), the owner is not necessarily the surface land owner; the subsurface could be separately owned. Recognition of, and the ability to acquire, the necessary rights to the land (including the sub-surface) is an important uncertainty to resolve prior to any commencement of on-site work during the surface-based investigations phase. However, this cannot be progressed until potential sites are identified.</p> <p>In securing access rights, the principles of transparency, fairness to both the land owners and the taxpayer, and alignment to the Government’s GDF siting process based on voluntarism will be respected.</p>	<p><i>With the exception of oil, gas, coal, gold and silver, the state does not own mineral rights in the UK – generally minerals are held in private ownership. Information on surface ownership and mineral rights, where available, is held by the Land Registry</i></p> <p><b>Overview</b></p> <p>UK Government policy is that the siting process for a GDF will be based upon voluntarism, as outlined in the 2014 White Paper <i>Implementing Geological Disposal</i>. RWM will require access to the land surface and rights to pierce and exploit the sub-surface strata, in order to carry out surface-based site investigations.</p> <p>RWM will seek to negotiate acceptable terms with land and mineral rights owners for access to, and use of, the land and the sub-surface strata, including any contained minerals, during the various phases of the GDF siting programme.</p>				
<b>Drivers</b>					
Commercial / Contractual	✓	Cost Impacts		Design Codes & Standards	
Disposal Concept Development		Disposal System Design		Disposal System Specification	
Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making	
NDA Strategy		Operational Safety Case		Programme / Risk Management	✓
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts	✓	Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability					
<b>Current Work Requirements</b>					
<p>Development of RWM’s approach to acquire land and mineral rights requires the employment of specialists in the field to fully understand the legal position and the options for acquiring both temporary and permanent land and mineral rights to enable progression of the GDF siting programme.</p> <p>A draft land access and implementation plan has been developed. To progress understanding further, a review of the current understanding of land ownership, land access rights and mineral rights is planned. This will investigate the risks that ownership and access to land carries, as well as providing an understanding of ownership of land in</p>					

Specification

Design

Assessment

Underpinning Knowledge Base

## S&T Programme – Assessments Major Products

Specification

England, Wales and Northern Ireland and methods available for committing to acquire, or acquire an interest in, that land. The work required to address the requirements of stakeholders and statutory consultees when seeking planning permission or environmental permits will also be considered so that a needs-driven plan can be established.

Once sufficient understanding of RWM’s responsibilities has been developed and a suitable strategy for land and mineral rights acquisition prepared, further activities cannot be progressed during the current generic phase of RWM’s programme, since the next steps would be inherently site-specific.

### Longer Term Work Requirements

Subsequent site-specific work will focus on the step-wise acquisition of land and mineral rights, in accordance with RWM’s strategy for the acquisition of land and mineral rights and in discussion with land (surface and sub-surface) owners. This process will be carried out in a manner commensurate with principles of transparency, fairness to both the land owners and the taxpayer, and alignment to the Government’s GDF siting process, based on voluntarism.

The step-wise acquisition of land and mineral rights would need to facilitate the following site investigation activities by RWM over the successive phases of siting and developing a GDF:

- During RWM’s planned and transitional activities, RWM will require rights to access to land at potential GDF sites to undertake environmental surveys that will feed into site evaluation and selection. These surveys are not expected to include intrusive work and will essentially require walk-over access.
- Early-on in the surface-based investigations phase, RWM will require rights to access the land to undertake non-intrusive surveys of the sub-surface environment; these will include seismic surveys and will involve a degree of penetration into the ground.
- Later in the surface-based investigations phase, RWM will require rights to access the land and the sub-surface to undertake intrusive surveys; these will involve the drilling of boreholes.
- In due course, during the construction and underground-based investigations phase, RWM would need to obtain rights to access the land to construct surface facilities and subsequently, to construct access ways and the underground component of the GDF.

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## 7 Major Products in the underpinning knowledge base work area

Development of a GDF for disposal of the UK’s higher activity radioactive waste and the provision of waste management solutions is based on scientific and technical knowledge and expertise. A large body of evidence from historical, recent and ongoing work on radioactive waste management, both in the UK and overseas, has been documented. This “knowledge base” underpins RWM’s programme.

RWM’s knowledge base is continually updated. Gaps in knowledge and uncertainties are identified through the iterative development process (Figure 2) and feed into planning for delivery of RWM’s S&T work programme (Section 2.3).

Activities to develop RWM’s underpinning knowledge base fall into three broad areas:

- Higher Activity Waste (HAW) Programme** (Major Product KB1). The upstream options project was a three-year project created to identify and implement opportunities to improve the management of higher activity wastes. The original project finished in March 2015 and the new HAW programme encompasses two work streams: HAW Upstream Options and HAW Strategic Delivery. HAW Upstream Options takes the technical lead in identifying, prioritising and delivering tasks, with SLCs, that are to be implemented in the near term to improve the management of HAW in the UK. HAW Strategic Delivery supports the NDA Strategy team on longer term projects to improve the management of HAW in the UK. The associated Major Product, KB1, sets out the programme planned under both of these work streams.
- Research and development (R&D)** (Major Products KB2 to KB17). RWM commissions R&D across eight topic areas, the scope of which are illustrated in Figure 18. Details of RWM’s R&D activities are captured in the S&T Plan (Major Product KB2) [4]. A suite of status reports summarises the status of RWM’s understanding relating to the various components of the disposal system (e.g. package evolution – Major Products KB3 and KB4), process pathways (e.g. gas – Major Products KB11 and KB12), and sets of accidental / unexpected conditions (e.g. waste package accident performance – Major Product KB15), and outlines how associated information needs will be addressed in RWM’s ongoing S&T Programme. Further detail on the approach to address information needs is provided in the task sheets within the S&T Plan [4]. Existing research status reports are generic, but site-specific versions will be developed in the future. The generic research status reports form part of the hierarchy of documents that constitute the generic DSSC, discussed in Section 6. These were first published in 2010. Updated versions of these status reports are being prepared and are planned for publication in FY 2016/17 as part of the next issue of the generic DSSC. These will cover current understanding of both the radiotoxic and chemotoxic implications of geological disposal of the UK’s higher activity waste.
- Site characterisation** (Major Products KB18 to KB22), which comprises detailed surface-based and subsurface investigations to acquire and interpret information on the geoscientific and environmental conditions at one or more sites throughout all stages of development and implementation of a GDF.

The underpinning knowledge base work area has 22 Major Products associated with it, as shown in Figure 19. The indicative schedule for producing these Major Products over the course of the GDF implementation programme is shown in Figure 20.

Specification

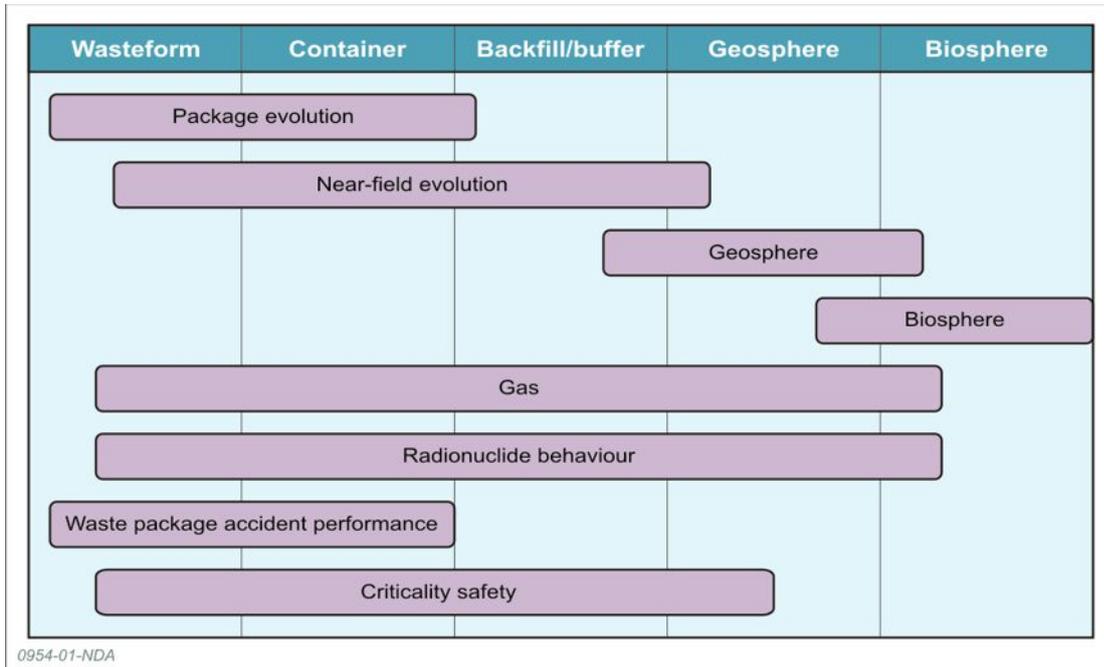
Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

Figure 18 S&T-based R&D topic areas



Specification

Design

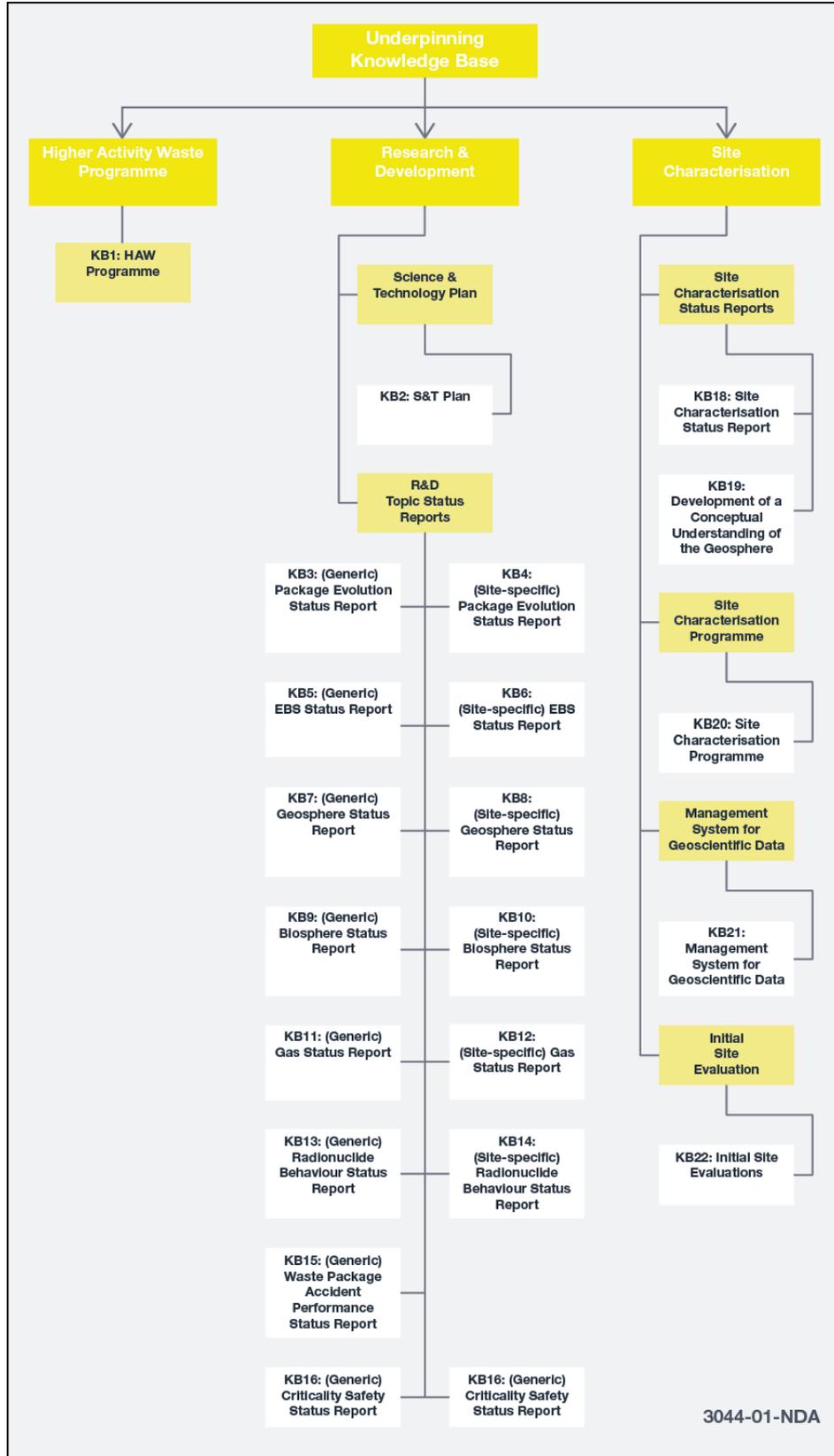
Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

Figure 19 Product breakdown structure for the underpinning knowledge base work area

Major Products are shown in white boxes



Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

Figure 20 Indicative schedule for the production of Major Products in the underpinning knowledge base work area

Specification

Design

Assessment

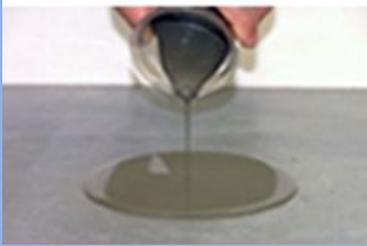
Underpinning Knowledge Base

WORK AREA		MAJOR PRODUCT	Current Activities	Planned Activities	Transitional Activities	Enabling Activities	Investigation Activities
Higher Activity Waste Programme	GENERIC	KB1: Higher Activity Waste Programme	Published	Maintain and Progress HAW Programme			
	Research & Development	GENERIC	KB2: Generic Science & Technology (S&T) Plan	Published	Maintain Generic S&T Plan		
GENERIC		KB3: (Generic) Package Evolution Status Report	Published	Maintain	Update	Maintain Package Evolution Status Report	
GENERIC		KB5: (Generic) EBS Status Report	Published	Maintain	Update	Maintain EBS Status Report	
GENERIC		KB7: (Generic) Geosphere Evolution Status Report	Published	Maintain	Update	Maintain Geosphere Status Report	
GENERIC		KB9: (Generic) Biosphere Status Report	Published	Maintain	Update	Maintain Biosphere Status Report	
GENERIC		KB11: (Generic) Gas Status Report	Published	Maintain	Update	Maintain Gas Status Report	
GENERIC		KB13: (Generic) Radionuclide Behaviour Status Report	Published	Maintain	Update	Maintain Radionuclide Behaviour Status Report	
GENERIC		KB15: (Generic) Waste Package Accident Performance Status Report	Published	Maintain	Update	Maintain Waste Package Accident Performance Status Report	
GENERIC		KB16: (Generic) Criticality Safety Status Report	Published	Maintain	Update	Maintain Criticality Safety Status Report	
GENERIC		KB2: Integrated Science & Technology (S&T) Plan			Develop	Publish	Maintain
Research & Development	SITE-SPECIFIC	KB4: (Site-specific) Package Evolution Status Report			Develop	Publish	Maintain
	SITE-SPECIFIC	KB6: (Site-specific) EBS Status Report			Develop	Publish	Maintain
	SITE-SPECIFIC	KB8: (Site-specific) Geosphere Status Report			Develop	Publish	Maintain
	SITE-SPECIFIC	KB10: (Site-specific) Biosphere Status Report			Develop	Publish	Maintain
	SITE-SPECIFIC	KB12: (Site-specific) Gas Status Report			Develop	Publish	Maintain
	SITE-SPECIFIC	KB14: (Site-specific) RN Behaviour Status Report			Develop	Publish	Maintain
	SITE-SPECIFIC	KB17: (Site-specific) Criticality Safety Status Report			Develop	Publish	Maintain
Site Characterisation	GENERIC	KB20: Generic Site Characterisation Programme	Published	Maintain	Update		
	SITE-SPECIFIC	KB18: Site Characterisation Status Report	Published	Maintain	Update	Maintain	
		KB19: Development of a Conceptual Understanding of the Geosphere	Published	Maintain	Update	Maintain	
		KB20: Site-specific Site Characterisation Programme(s)		Develop	Publish	Maintain, Update & Apply	
		KB21: Management System for Geoscientific Data		Develop		Maintain & Apply	
		KB22: Initial Site Evaluations			Develop	Publish	Maintain

3045-01-NDA

# S&T Programme – Underpinning Knowledge Base MPs

## Higher Activity Waste (HAW) Programme (Major Product KB1)

<p><b>Purpose</b></p> <p>To identify and implement opportunities to improve the management of HAW and lead to value for the NDA and the wider industry. Value may be in terms of cost savings, reduced environmental detriment, quicker hazard reduction, etc.</p>		Specification																														
<p><b>Information needs and strategic objectives</b></p> <p>The strategic objective for the HAW Programme is: <i>“in conjunction with NDA, other functions within RWM and with waste producers, identify and deliver solutions to optimise the management of Higher Activity Waste”</i>.</p> <p>To deliver this objective, ongoing and constructive engagement will be needed with NDA and with Waste Producers. A prioritised programme of work will be created which reflects the needs of NDA and SLCs.</p>																																
<p><b>Current Work Requirements</b></p> <p>Since disposal in a GDF represents the end of the lifecycle the disposal system requirements place constraints on earlier parts of the waste lifecycle. The prioritised programme will be updated periodically to ensure it supplies most value. Current work planned for the HAW Programme includes:</p> <ul style="list-style-type: none"> <li>➤ Produce manufacturing specifications for stainless steel containers.</li> <li>➤ Development of a Standard Waste Transport Container, based on user requirements.</li> <li>➤ Improved management of tritium contaminated waste.</li> <li>➤ The potential use of geopolymers as a waste encapsulant.</li> <li>➤ Support to NDA on Scottish Policy Implementation.</li> <li>➤ Improved coordination in the management of problematic waste.</li> <li>➤ Thermal treatment technologies.</li> </ul>	<p><b>Overview</b></p> <p>The Higher Activity Waste (HAW) programme was created to progress opportunities to optimise the management of higher activity wastes, spent fuel and other materials that may be disposed of in the GDF. This work area considers the waste lifecycle from retrieval through to disposal in a GDF, and the impacts that activities in the RWM S&amp;T Programme, NDA Strategy or SLC plans may have on those lifecycles.</p>	Design																														
<p><b>Longer Term Work Requirements</b></p> <p>This work is generic and is not linked to siting. As the project progresses a decision will be made on the prioritisation of work opportunities required in future years. It is anticipated that this prioritisation process for identified work opportunities will be based on the existing NDA value framework arrangements, which include a number of factors such as hazard reduction, safety and security improvements, environmental impact, societal impact and cost income. The decision to proceed with identified opportunities or specific strategic requirements from the NDA will be determined through dialogue between RWM and NDA Strategy. It is anticipated that there will be a continuing need to engage with waste producers to determine new opportunities to optimise the management of higher activity wastes.</p>		<p>The HAW programme encompasses two work streams: 1) HAW Upstream Options – this takes the technical lead in identifying, prioritising and delivering tasks, with SLCs, that are to be implemented in the near term to improve the management of HAW in the UK, and 2) HAW Strategic Delivery – this supports the NDA Strategy team on longer term projects to improve the management of HAW in the UK.</p>	Assessment																													
<p><b>Drivers</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Commercial / Contractual</td> <td style="width: 10%;"></td> <td style="width: 33%;">Cost Impacts</td> <td style="width: 10%; text-align: center;">✓</td> <td style="width: 14%;">Design Codes &amp; Standards</td> <td style="width: 10%;"></td> </tr> <tr> <td>Disposal Concept Development</td> <td style="text-align: center;">✓</td> <td>Disposal System Design</td> <td></td> <td>Disposal System Specification</td> <td></td> </tr> <tr> <td>Environmental Impact &amp; Sustainability</td> <td style="text-align: center;">✓</td> <td>Environmental Safety Case</td> <td></td> <td>Flexibility in Decision Making</td> <td style="text-align: center;">✓</td> </tr> <tr> <td>NDA Strategy</td> <td style="text-align: center;">✓</td> <td>Operational Safety Case</td> <td></td> <td>Programme / Risk Management</td> <td style="text-align: center;">✓</td> </tr> <tr> <td>Waste Package Disposability</td> <td style="text-align: center;">✓</td> <td></td> <td></td> <td></td> <td></td> </tr> </table>			Commercial / Contractual		Cost Impacts	✓	Design Codes & Standards		Disposal Concept Development	✓	Disposal System Design		Disposal System Specification		Environmental Impact & Sustainability	✓	Environmental Safety Case		Flexibility in Decision Making	✓	NDA Strategy	✓	Operational Safety Case		Programme / Risk Management	✓	Waste Package Disposability	✓				
Commercial / Contractual		Cost Impacts	✓	Design Codes & Standards																												
Disposal Concept Development	✓	Disposal System Design		Disposal System Specification																												
Environmental Impact & Sustainability	✓	Environmental Safety Case		Flexibility in Decision Making	✓																											
NDA Strategy	✓	Operational Safety Case		Programme / Risk Management	✓																											
Waste Package Disposability	✓																															

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Science and Technology Plan (Major Product KB2)

Specification

### Purpose

To identify, schedule and foster opportunities for discussion of RWM’s generic research plans.

### Information needs and strategic objectives

The status reports support RWM’s strategic objective to:

*“Deliver a focused R&D programme to support geological disposal and optimise package solutions”*

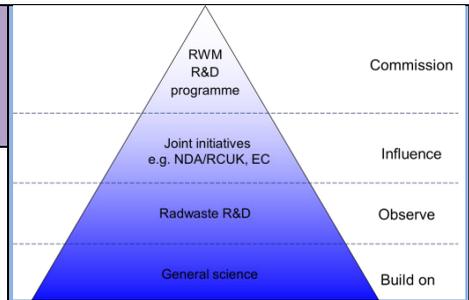
Having undertaken three decades of research into the geological disposal of UK wastes, significant progress has been made. Challenges to the viability of geological disposal concepts have been overcome and the remaining key uncertainties are currently subject to large focused research projects. Such tasks are identified in the Science and Technology Plan, together with the remaining generic body of research and development required to address knowledge gaps associated with the Disposal System Safety Case, disposal concept development and disposal system design. This increased knowledge base may in turn be reflected in improvements to the waste disposability assessment process through the elimination of unwarranted conservatisms. The S&T Plan was first published in September 2014 and an updated version has been published in conjunction with this document.

RWM uses the concept of Scientific Readiness Levels (SRLs®) as a mechanism for calibrating the maturity of underpinning science across different topic areas, and for plotting a route to attain the required level of understanding through future R&D activities. SRLs® are similar to Technology Readiness Levels (TRLs), discussed under Major Product DE13, and used by RWM to evaluate the maturity of engineering design-based activities. However, SRLs® are considered by RWM to be more appropriate for evaluating the scientific robustness of understanding of underlying science. Further discussion of SRLs® is provided in the S&T Plan [1].

Design

Assessment

Underpinning Knowledge Base

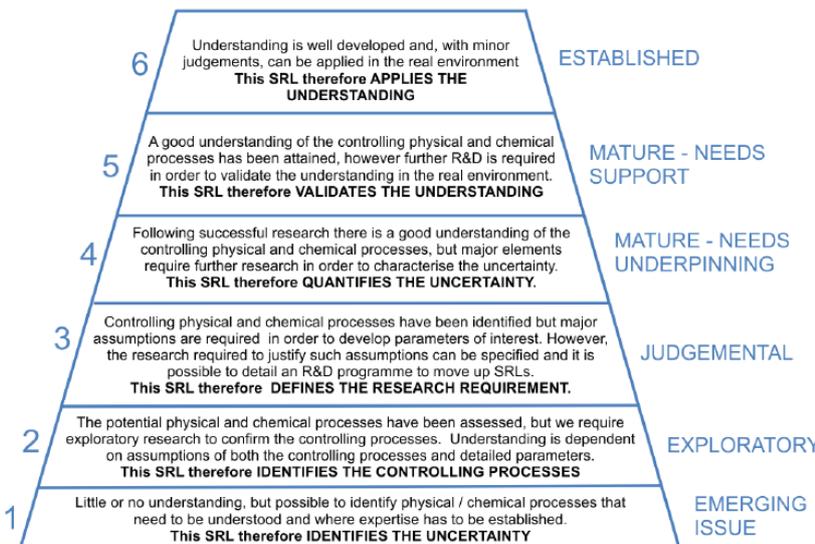


**As well as procuring research from the RWM supply chain, there is also extensive collaboration seeking to influence national and international shared research. RWM also observes and builds on work done elsewhere**

### Overview

The Science and Technology (S&T) Plan presents an analysis of the nature and timing of RWM’s future generic research and development activities. ‘Generic’ refers to those activities that can be undertaken without specific knowledge of the eventual host site for the GDF. The plan is primarily an internal document; however its publication provides opportunities for dialogue and involvement of interested parties in the development of the knowledge base for the safe geological disposal of radioactive waste. The plan covers an approximately 10-year planning window.

### Scientific Readiness Levels



2449-01-NDA

Schematic representation of the Scientific Readiness Level (SRL®) scale

## S&T Programme – Underpinning Knowledge Base MPs

<b>Drivers</b>					
Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability	✓	Environmental Safety Case	✓	Flexibility in Decision Making	✓
NDA Strategy	✓	Operational Safety Case	✓	Programme / Risk Management	✓
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts	✓	Stakeholder Engagement	✓	Transport Safety Case	✓
Waste Package Disposability	✓				
<b>Current Work Requirements</b>					
The S&T Plan will be periodically reviewed, updated and re-published as RWM’s generic S&T programme progresses, as tasks are completed, and as new tasks are identified and factored into forward prioritisation of work.					
<b>Longer Term Work Requirements</b>					
As the siting process progresses the generic S&T Plan will be maintained for a period, however as the programme transitions to become increasingly site-specific, it will be developed into the “integrated” S&T Plan. This will review any remaining R&D needs from the generic programme and will re-scope them in the context of the site(s) under investigation.					
<b>References</b>					
[1] Radioactive Waste Management Limited, <i>Geological Disposal: Science and Technology Plan</i> , NDA/RWM/121, Version 2, 2015.					

Specification

Design

Assessment

Underpinning Knowledge Base

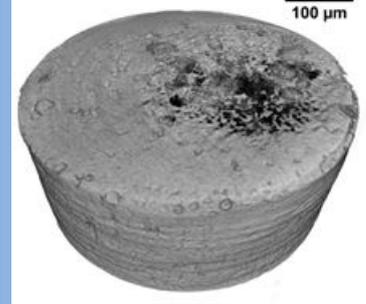
# S&T Programme – Underpinning Knowledge Base MPs

## Package Evolution Status Reports (Major Products KB3 & KB4)

Specification

### Purpose

To summarise the evidence showing that durable waste packages, able to withstand their storage and disposal environments for the timescales required, have been or can be produced for all components of the disposal inventory.



*Improved understanding of corrosion processes of ILW containers, for example how the development of pits in stainless steel progresses upon exposure to a corrosive solution, has been developed from 3D-tomography studies at the Diamond Light Source synchrotron facility*

Design

### Strategic objectives and sources of information

The package evolution status report supports RWM’s strategic objective to:

*“Deliver a focused R&D programme to support geological disposal and optimised packaging solutions”.*

The package evolution status report describes RWM’s understanding of the likely evolution of wasteforms and waste containers during periods of storage and after disposal in a GDF. The report documents RWM’s understanding, gained through:

- An extensive programme of RWM funded R&D activities.
- Learning from other waste management organisations.
- Research funded or carried out by other parties, such as waste owners, the UK Research Councils or the European Commission.

### Overview

Using the term ‘waste package’ RWM considers both the wasteform (e.g. for ILW/LLW a cementitious, thermally treated or polymeric monolith) and the container (for ILW/LLW typically stainless steel).

The package evolution status report supports the transport, operational and environmental safety cases by summarising evidence relating to the topic of package evolution. It describes the wastes and their long-term management, identifies the safety functions of waste packages and describes the design, manufacture, storage and disposal of waste packages. It discusses the likely evolution of wasteform and waste container materials under different environmental conditions and presents evidence demonstrating their durability from a variety of information sources.

Understanding from this research is used to develop representative models of how packages behave during storage and over the long term.

Assessment

### Scope of the generic package evolution status report

The scope of the generic package evolution status report includes:

- The evolution of UK HLW glasses, including Magnox, Blend and other specific formulations.
- The evolution of UK spent fuels, including advanced gas-cooled reactor (AGR) fuel, pressurised water reactor (PWR) fuel, metallic (e.g. unreprocessed Magnox-type) fuel and, to a lesser extent, Exotic fuel, MOX fuel (for the immobilisation of plutonium) and fuel from new nuclear power stations.
- The evolution of cement-based encapsulants and their interaction with specific ILW/LLW, including wastes containing reactive metals, organic materials and mobile wastes.
- The evolution of ILW/LLW immobilised through the use of organic (polymeric) encapsulants or high temperature processes (e.g. vitrification) to identify alternative options which, for some wastes, could provide benefits relative to encapsulation in cement.
- The evolution of wastes such as graphite or bulk, unreactive metals that may be suitable for disposal without encapsulation.
- To a small extent, the evolution of potential wasteforms for the immobilisation of any plutonium not used in the manufacture of MOX fuel (e.g. plutonium residues), as well as uranium (particularly depleted, natural and low enriched uranium, DNLEU).
- The evolution of waste containers currently envisaged for the storage and disposal of ILW/LLW, including containers manufactured in stainless steel, others ‘steels’ (e.g. carbon steel or cast iron) and concrete.
- The evolution of waste containers currently envisaged for the disposal (and in some cases storage) of HLW and spent fuel, including containers manufactured in copper, ‘steels’ (e.g. carbon steel or cast iron), titanium, nickel alloys and stainless steel.

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

Drivers					
Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	✓
NDA Strategy	✓	Operational Safety Case	✓	Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning		Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	✓
Waste Package Disposability	✓				
<p><b>Notes:</b> This topic area addresses stakeholder issues concerning the evolution of vitrified HLW, spent fuel, plutonium and ILW wasteforms and the evolution of waste containers for ILW/LLW, HLW and spent fuel. For wastes whose disposal concept(s) are at earlier stages of development, current and future work is aimed at developing understanding of the available options to support future waste packaging decisions. More work may be carried out in the future pending strategic decisions on the management of such materials. R&amp;D activities in the package evolution research area are also driven by requirements from disposability assessments (Major Product AS13). This helps to maintain an appropriate focus and prioritisation of research needs as innovative packaging proposals are received from SLCs.</p>					
<p><b>Longer Term Work Requirements</b></p> <p>Future generic and site-specific iterations of the package evolution status report will need to be produced in conjunction with preparation and update of the other research status reports, such that the suite of status reports reflects RWM’s latest understanding, and its plans for future research, as set out in the Science and Technology Plan. It is planned that the status reports will be updated each time RWM’s Disposal System Safety Case is revised, so the schedule for updating the status reports is strongly dependent on requirements for the update of the three main safety case reports and associated documents.</p> <p>The evolution of both waste containers and wasteforms is strongly influenced by the chemistry of the environment they come into contact with. In a GDF, the environment is influenced both by the near-field barriers and by the chemistry of inflowing groundwater from the surrounding rocks. Therefore, once one or more sites are under consideration, information on groundwater chemistry at the site will be required to confirm (or otherwise) RWM’s understanding of the evolution of wasteforms and containers developed previously through generic activities, when applied to site-specific conditions. During these surface-based investigations, site-specific groundwater samples will be collected and analysed to identify the range of water chemistries expected to come into contact with waste containers and, after failure of the container, with the wasteform. Related R&amp;D is expected to include both modelling and laboratory experiments to build confidence in expected processes and to acquire the necessary information for safety assessments. In addition, long-term laboratory-based demonstration experiments may be carried out. Whilst groundwater chemistry is the key site-specific information required to develop a robust and mature understanding of package evolution, other site-specific information may also be required, for example information about microbial populations in the geosphere and their transport/survivability through the near field barriers, and information about the evolving stress field in a GDF.</p>					
<div style="display: flex; justify-content: space-around;">    </div>					
<p><i>Research is planned or in progress on AGR spent fuel (left), reactor graphite (middle) and spent fuel deposition products (right)</i></p>					

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Engineered Barrier System Status Reports (Major Products KB5 & KB6)

Specification

### Purpose

To summarise the supporting evidence showing how the engineered barriers of the disposal system work together to assure long-term safety.

### Information needs and strategic objectives

The EBS status report supports RWM’s strategic objective to:

*“Deliver a focused R&D programme to support geological disposal and optimised packaging solutions”.*

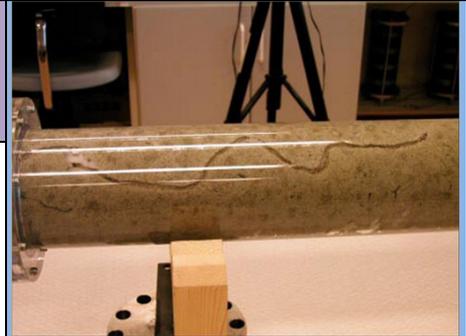
The EBS status report describes RWM’s understanding of how the EBS of a GDF (defined as the engineered barrier system (including the wasteform, waste containers, buffer materials, backfill, and seals) evolves. The report documents RWM’s understanding, gained through an extensive programme of RWM funded R&D activities, learning from other waste management organisations and research funded or carried out by other parties, such as waste owners. This information is used to develop representative models of how the EBS behaves over the long term, and thus how it influences the containment and retardation of radionuclides. As disposal concepts are developed and incorporated into the design of the GDF, RWM’s evolving understanding of how the associated engineered barriers are anticipated to behave will be incorporated into the subsequent development of modelling in support of post-closure safety.

### Scope of the EBS status report and current work requirements

The engineered barrier system will be compatible with the wastes to be disposed of and the host geology. Some of these barriers (for example the waste container and wasteform) are the focus of other status reports. Therefore, much of the work in the EBS work area focuses on the buffer, backfill and seals. All research concerning radionuclide behaviour in the EBS is addressed in the radionuclide behaviour research area.

Specific objectives for R&D relating to the EBS are:

- Understanding and modelling of key EBS evolution processes in a GDF for ILW/LLW and for HLW/SF.
- To provide data and understanding to support the ESC.
- To gather information that may be needed to inform future engineering and concept selection decisions.



Photograph of a channel formed by piping during a test in which a 1% salt solution was passed at a flow rate of 0.1 l/min through bentonite pellets in a Plexiglas tube. 1395-01-S&B/NDA

**Laboratory-based experiments can be used to investigate potentially detrimental processes that might occur in the EBS, such as “piping” (formation of flow channels” in a bentonite buffer / backfill)**

### Overview

The engineered barrier system (EBS) status report details RWM’s understanding of EBS evolution and how this affects post-closure safety. This feeds, in particular, into the generic environmental safety case (ESC). The EBS status report includes a discussion of how different engineered barriers contribute to the ESC, together with generic and host-rock specific descriptions of EBS evolution.

Design

Assessment

Underpinning Knowledge Base

### Drivers

Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	✓
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability	✓				

# S&T Programme – Underpinning Knowledge Base MPs

<p><b>Current Work Requirements</b> (continued)</p> <p>In the current phase of its work programme, RWM aims to continue to build its understanding of EBS evolution by studying concepts for engineered barrier systems that have been developed internationally. At the present time, RWM’s EBS research activities, detailed in the S&amp;T Plan, are divided into a number of sub-topics. These are:</p> <ul style="list-style-type: none"> <li>➤ Heat generation from the emplaced waste and associated thermal effects.</li> <li>➤ The evolution of cementitious backfills due to reactions with groundwater solutes, with waste package constituents and with their degradation products (e.g. CO<sub>2</sub>) and long-term thermal ageing effects.</li> <li>➤ The potential effects of void spaces, and their evolution, on performance.</li> <li>➤ Resaturation and evolution of bentonite-based buffers due to thermal and irradiation effects, and interactions with other materials in the GDF (e.g. due to the co-location of wastes disposed of using different disposal concepts).</li> <li>➤ Porewater evolution in the EBS.</li> <li>➤ System interactions and coupled processes.</li> </ul> <p>As regards the latter topic, RWM conducts extensive research into the evolution of multiple barriers and the implications of coupled effects. To do this RWM considers how processes researched within other research topics (and hence, captured in other status reports) will impact on EBS evolution. Such processes include:</p> <ul style="list-style-type: none"> <li>➤ Creation and recovery of an excavation damaged zone (EDZ) (considered in the geosphere status report).</li> <li>➤ Desaturation and oxidation of the host rock surrounding the EBS during the operational phase (considered in the geosphere status report).</li> <li>➤ Host rock creep (considered in the geosphere status report).</li> <li>➤ Container and wasteform degradation (considered in the package evolution status report).</li> <li>➤ Gas generation due to corrosion (considered in the gas status report), and its potential to affect EBS performance.</li> </ul> <p>Issues within the following topics relate to EBS evolution, and will be addressed by activities in the EBS work area, which will feed into the EBS status report:</p> <ul style="list-style-type: none"> <li>➤ Long-term cement backfill evolution.</li> <li>➤ Resaturation and long-term evolution of clay-based buffers.</li> <li>➤ System interactions and the near-field component model for ILW.</li> </ul> <p>Larger-scale, long-term laboratory experiments are also likely to be undertaken to develop RWM’s understanding; these might have durations of between 5 to 10 years. RWM is building on its participation in collaborative URL projects to design and undertake these site-specific demonstration experiments.</p>	<p>Specification</p>
<p><b>Longer Term Work Requirements</b></p> <p>The chemical and physical evolution of the EBS is influenced by interaction of the barrier materials with the groundwater that flows into and through the GDF from the surrounding rocks. Interaction with cementitious barriers results in mineralogical alteration of the cement minerals and changes to the porosity and permeability of the barrier. The nature of the alteration is influenced by the groundwater chemistry and will therefore require site-specific investigation. In the case of clay-based barriers, groundwater chemistry influences the swelling pressure attained by the barrier, the potential for its erosion and its mineralogical evolution.</p> <p>Site-specific R&amp;D on interactions between engineered barriers and groundwater is expected to involve both modelling and laboratory experiments to build understanding of processes and to acquire the necessary information for assessment models. Another major theme for the site-specific stage is the potential need to develop a suitable cementitious backfill should a low strength sedimentary rock environment be considered. Once the new backfill had been developed, groundwater chemistry issues as described above would be addressed. There are also a number of other issues where site-specific information may be required to support EBS research. For example, an understanding of the survivability of geosphere microbes in the EBS and understanding of the thermal evolution of the GDF and its host rock will require site specific measurements.</p>	<p>Design</p>
	<p>Assessment</p>
	<p>Underpinning Knowledge Base</p>

# S&T Programme – Underpinning Knowledge Base MPs

## Geosphere Status Reports (Major Products KB7 & KB8)

Specification

### Purpose

To summarise the behaviour and evolution of the geosphere surrounding a GDF, including the impacts of disturbances to natural conditions caused by the GDF itself and the influence of external features, events and processes on the disposal system. The geosphere status report presents supporting evidence from R&D showing how the geosphere contributes to long-term safety by providing isolation and containment of the wastes.



*RWM's collaborative use of overseas underground research facilities such as Åspö in Sweden addresses generic knowledge gaps as well as providing experience in undertaking geosphere studies*

Design

### Information needs and strategic objectives

There are two high-level safety objectives of geological disposal of radioactive waste, namely to isolate the waste from the surface environment and to contain the radionuclides associated with the wastes over very long time periods. In order to assure that these objectives are delivered, a GDF is designed as a multiple-barrier system. This involves benefitting from bespoke engineered barriers designed to work together and in combination with the natural barrier afforded by the geosphere.

A suitable geological setting for a GDF will isolate the wastes from the effects of natural events, will reduce the potential for inadvertent human intrusion, and will have adequate stability and predictability over long timescales – meeting these requirements is fundamental to geological disposal.

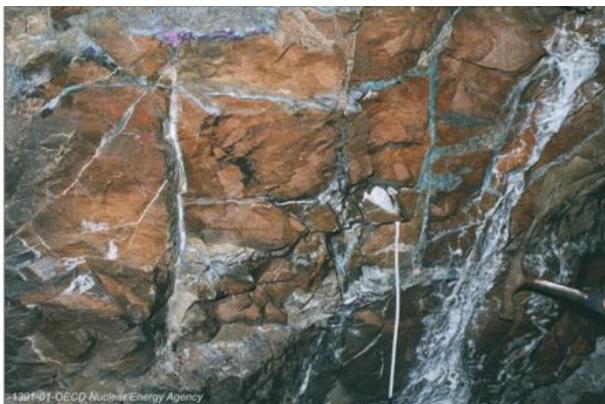
Since a process of voluntarism is being used to select a site, the geological setting for a UK GDF is not presently known. However, there are examples from overseas radioactive waste management programmes where facilities are being developed in three broadly-categorised host rocks types; these host rocks are used in the illustrative concepts developed for a UK GDF (see Major Product SP5), and draw on significant related international experience. In keeping with a 'needs-driven' programme, RWM's current approach is to maintain an understanding of key geosphere processes, and of work undertaken in overseas programmes, as well as to carry out generic research into specific aspects, such as sealing of site investigation boreholes, as required. RWM will continue to participate in a number of international studies in order to gain access to relevant site-based information, to demonstrate capabilities and to enhance its experience.

### Overview

The generic Geosphere Status Report provides a summary of the contribution of the geosphere as part of a multiple-barrier concept for geological disposal of radioactive waste. It also explains how RWM can use the understanding of the properties of the geosphere and its expected evolution over time periods of relevance to build confidence in the safety of geological disposal.

There are many different geological settings in England and Wales that may potentially be suitable for a GDF. This report discusses the possible future behaviours of the geosphere in the context of three illustrative geological settings. The natural processes that theoretically could impact on the geosphere in a UK geological setting over the timescale of the next million years or so and that are potentially relevant to geological disposal include climate change and related consequences (e.g. glaciation and permafrost), seismicity, erosion / deposition and uplift / subsidence.

Assessment



*Photograph of fractures sealed by calcite due to the passage of high pH fluids through a fractured zone at Maqarin in Jordan – a natural analogue that could provide information on how migrating fluids from a cementitious GDF might interact with any fractures in the host rock*

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

Drivers					
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	✓
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results	✓	Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability	✓				
Current Work Requirements					
<p>Specific objectives for geosphere R&amp;D are to:</p> <ul style="list-style-type: none"> <li>➤ Underpin the understanding of the expected evolution of the geosphere in response to natural processes such as future climate change, including the effects of permafrost and glaciation.</li> <li>➤ Underpin descriptions of the potential impact of a GDF on a natural geological setting, for example by understanding the evolving extent and properties of any chemically disturbed zone around a GDF.</li> </ul> <p>To achieve these objectives, RWM’s future geosphere work programme is currently divided as follows:</p> <ul style="list-style-type: none"> <li>➤ Natural evolution of the geosphere, including consideration of: tectonics; uplift, erosion and subsidence; impacts of future climate change and how groundwater movement and chemistry at GDF-relevant depths could be affected.</li> <li>➤ Impact of the GDF on the geosphere, comprising developing understanding of coupled thermal, hydrogeological, mechanical, chemical and biological (THMCB) processes.</li> </ul> <p>Coupled processes are a major area of generic geosphere research. The aim is to enhance understanding of how groundwater movement and its properties, and GDF-derived gas movement, are affected by a range of processes that operate in the vicinity of a GDF. RWM considers it is more desirable to understand a geosphere system as a whole and the appropriate couplings between THMCB processes occurring therein than to address these processes individually.</p> <p>Planned geosphere research activities, which will feed into future updates of the geosphere status report, include:</p> <ul style="list-style-type: none"> <li>➤ Studies of groundwater flow, including its representation in numerical models for a range of illustrative geological environments.</li> <li>➤ Impact of GDF-related coupled THMCB processes on the geosphere, including interactions between GDF components and the geosphere. Ongoing work in this area includes consideration of the potential for uplift of the land surface due to heating of the rock mass by waste in a GDF.</li> <li>➤ Evolution of the geosphere, including impacts of natural processes (e.g. seismicity, glaciation) on GDF performance.</li> <li>➤ The use of natural and industrial analogues.</li> <li>➤ Understanding the role of the excavation damaged zone (EDZ) in the context of the post-closure safety assessment and any associated design requirements.</li> </ul>					
Longer Term Work Requirements (site-specific stage of programme)					
<p>Once a site, or sites, is identified, a significant site-specific research programme will be undertaken that builds on the knowledge and experience RWM is developing through its generic research and its participation in international projects. RWM will develop a site-specific understanding of both the natural evolution of the geosphere, addressing issues such as the impact of future climate change-related processes such as glaciation and permafrost on GDF performance, and of interactions between a GDF and the geosphere. Future versions of the geosphere status report may be structured differently from the generic geosphere status report, depending on requirements.</p> <p>Site-specific research into natural geosphere evolution will additionally use the understanding developed through site descriptive models and through the biosphere research programme, in conjunction with understanding from the geosphere research programme, to predict the potential impacts of future climate change on GDF performance and to consider future uplift/subsidence and erosion/deposition. The potential for future earthquakes and faulting will also be considered on a site-specific basis.</p> <p>RWM will also continue a long-term generic component to its geosphere research programme including continuing its active participation in international projects in overseas URLs, to build knowledge and understanding that is transferable to implementing a GDF in the UK and to add value to international collaborative projects.</p>					

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Biosphere Status Reports (Major Products KB9 & KB10)

Specification

### Purpose

To summarise RWM’s approach to representing the biosphere in the disposal system safety case.



**RWM is supporting the NERC TREE programme, which includes a study on wildlife roaming patterns in the Chernobyl Exclusion Zone**

Design

### Information needs and strategic objectives

The biosphere status report sets out RWM’s approach to representing the biosphere in the ESC. In the context of post-closure safety, which typically addresses timescales of hundreds of thousands to millions of years, consideration of the biosphere is needed for two reasons:

- Firstly, the biosphere acts as the receptor for any contaminants that may be released from the geosphere, defines their distribution in the environment and is where key end-points relating to the effectiveness of the disposal system are determined. This includes estimation of the very low environmental concentrations and the associated exposure of humans and other organisms arising from releases from the GDF many thousands of years in the future. In assessment modelling, the transport of radionuclides through the biosphere is represented so that concentrations in environmental media (e.g. soil) can be estimated and are used to determine the potential exposure of humans and non-human biota to radiation (focusing on the potentially most exposed group within the population).
- Secondly, consideration of processes associated with the long-term evolution of the biosphere is important in defining the boundary conditions for the geosphere (e.g. changes in climate, topography and/or land-use determine groundwater recharge rates and the associated chemistry for the deeper groundwater system). This also enables the identification of potential sources of disturbance (e.g. the effects of permafrost and glacial scouring) to the safety functions provided by different barriers within the disposal system.

### Overview

The biosphere status report focuses on post-closure issues and supports the Environmental Safety Case (ESC), as well as the Operational Environmental Safety Assessment (OESA) and Environmental Assessments.

The report describes the key processes and understanding underpinning the representation of the biosphere in the post-closure safety case, (for example, by describing how the biosphere may evolve over the long time-scales of relevance to post-closure safety and by identifying key radionuclides). It describes the conceptual and mathematical models adopted for assessment purposes. Emphasis is placed on potential releases of radionuclides from a GDF that may reach the biosphere by transport in groundwater. However the radiological impact of gas generation and its migration and behaviour in the biosphere is also covered.

RWM’s approach to represent the biosphere in post-closure assessments has been developed over the past 20 years. It is fully informed by approaches identified as international best practice and pioneered by overseas waste management organisations.

Assessment

It is recognised that the biosphere will evolve. Therefore, in long-term safety assessments the future biosphere is represented by stylised scenarios, based on an understanding of current and past environments. Much of RWM’s ongoing research work is therefore to ensure that models encompass the range of conditions that could reasonably be expected to occur. This approach is in line with international guidance that has also been adopted by overseas waste management organisations.

Illustration	Climate State & Notes
	<b>Sub-tropical (semi-arid):</b> Susceptible to erosion, but stable under good land management; long period of erosion and aggregation of fine sediments in the valley bottom progressively reduces relief; water is scarce and managed for farming, including irrigation.
	<b>Temperate:</b> Catchment relief may be limited; fertile soils in the valley floors intensively farmed.
	<b>Periglacial</b> Incision and aggregation of coarser sediments; continued isostatic adjustment; likely to be extensive hunting and herding activities.
	<b>Glacial:</b> Potential for glacial scouring, along with further incision and aggregation of coarser sediments; continued isostatic adjustment; unlikely to be permanent human occupancy.

**Stylised climate scenarios used in post-closure safety assessment – a range of climate states may prevail at the GDF over the timescales relevant to long-term safety assessment**

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

Drivers					
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	✓
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability	✓				
<p><b>Current Work Requirements</b></p> <p>It has been helpful to work with other organisations internationally, collaborating towards common goals and sharing existing knowledge. Recent and ongoing projects in which RWM has been involved include:</p> <ul style="list-style-type: none"> <li>➤ The IAEA BIOMASS project [1], which developed an overall biosphere assessment methodology.</li> <li>➤ The collaborative EU-funded BIOCLIM project [2], which has established an international consensus regarding the interpretation and representation of long-term climate change within biosphere assessments.</li> <li>➤ The ongoing collaborative BIOPROTA project, which draws together international experience regarding key pathways and contaminants in biosphere assessments and maintains close contacts with other waste management organisations with an interest in biosphere assessment issues.</li> <li>➤ The IAEA MODARIA project [3], which reviewed modelling practices and data for radiological impact assessments.</li> </ul> <p>RWM has also taken note of the EU-funded FASSET, EPIC, ERICA and PROTECT projects, which have led the development of an agreed approach to assessing potential impacts on environmental / non-human biota end-points and will inform forthcoming recommendations of the International Commission on Radiological Protection in this area.</p> <p>Radiological effects on non-human biota is an area where further generic research may be required. RWM is already supporting a study in this area in collaboration with the Natural Environment Research Council (NERC).</p>					
<p><b>Longer Term Work Requirements</b></p> <p>Once one or more sites are under consideration, site-specific biosphere models will be produced, using the approach developed through generic research studies. The catchment model is an important component of the biosphere model. It describes the near-surface hydrology and ‘points of contact’ in the biosphere. It interfaces with the geosphere model, which contains the description of the groundwater environment, via the biosphere – geosphere interface. Currently, this model is generic; it will be developed to represent the site once this is known. Ongoing development of the catchment model will continue during site characterisation as geosphere understanding improves.</p> <p>RWM has already produced terrestrial models for glacial, tropical, temperate, boreal and glacial climate states. RWM recently developed a marine model corresponding to a temperate climate state and is considering whether marine models are required for the other climate states. Climate predictions in a European context will be down-sized to regional, and ultimately, the local scale once one or more sites are under consideration. Since climate change science is evolving rapidly, RWM will continue to undertake generic research in this area through international collaborations.</p> <p>There are other topics where site-specific biosphere research may be required. For example, RWM’s non-human biota model (ERICA) is currently supported by a generic database. A site-specific ERICA database may be required in the future. RWM may also study the behaviour of some key radioelements (for example, iodine, technetium, uranium, selenium and radon) in site-specific soils and vegetation. This may be undertaken through field-scale lysimeter experiments similar to those previously undertaken in the generic research programme.</p>					
<p><b>References</b></p> <p>[1] IAEA, “Reference Biospheres” for Solid Radioactive Waste Disposal: Report of BIOMASS Theme 1 of the BIOSphere Modelling and ASSESSment (BIOMASS) programme, IAEA Report IAEA-BIOMASS-6, 2003.</p> <p>[2] BIOCLIM, Deliverable D10-12: Development and Application of a Methodology for taking Climate-driven Environmental Change into account in Performance Assessments, published by ANDRA), 2004.</p> <p>[3] MODARIA, “Proposals for Themes for the IAEA’s model testing and comparison programme: MODARIA: Modelling and Data for Radiological Impact Assessments”, IAEA, May 2012.</p>					

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Gas Status Reports (Major Products KB11 & KB12)

Specification

Design

Assessment

Underpinning Knowledge Base

### Purpose

To document RWM's understanding of the generation and migration of radioactive trace gases and bulk gases in a UK GDF.

### Information needs and strategic objectives

The formation of gases from processes occurring in waste packages and other EBS components is unavoidable, and gases will be generated during transport, operations and after closure of a GDF. The impact of gases on the safety case falls into two broad areas: firstly, the effects associated with the production of non-radioactive (bulk) gases and secondly, the radiological impacts of (trace) gases containing radionuclides such as tritium, carbon-14 and radon-222.

The key gas generation processes applicable to a GDF are the corrosion of metals, degradation of organic materials and radiolysis. Hydrogen would be the predominant gas formed, principally from metal corrosion, with lesser amounts of methane and carbon dioxide formed from degradation of organic materials. In addition, radioactive gases and some chemotoxic species may also be formed. The relative importance of the various generation processes, and hence the rates of gas formation and the gas composition, depend on the wastefrom and variables such as water availability and water composition, which will depend on the host rock and the disposal concept.

Migration of gas within the EBS and through the rocks surrounding the GDF will also depend on the geological disposal concept and the individual site(s) being considered. Research aims to build understanding of the processes by which gas moves through a range of relevant geological and engineering materials, and to develop models to represent those processes. In the absence of a site, RWM's research into gas migration issues of relevance to GDF performance assessment is currently undertaken through participation in the international FORGE (*Fate Of Repository Gases*) project. This ensures that RWM gains access to relevant site-based information and develops its capabilities and experience.

### Current Work Requirements

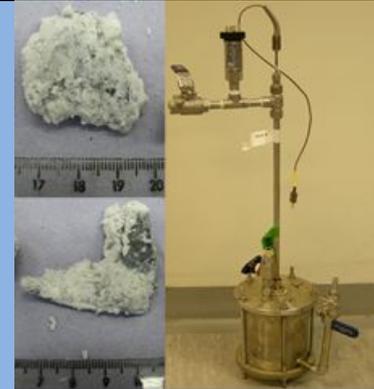
The gas generation and migration work area aims to:

- Understand the generation and release of bulk gases and radioactive trace gases from wastefroms and waste packages, to support the transport, operational and post-closure safety cases in the DSSC.
- Understand gas migration and reactions in the EBS and surrounding geosphere, to support the post-closure safety case in the DSSC.

Generic research in this area covers a number of topics, including:

- Carbon-14 release from ILW.
- Bulk gas generation from ILW, and gas generation from HLW and spent fuel, and potential impacts on the disposal system.
- Gas migration and reaction.

Research on carbon-14 is driven both by the requirements of the DSSC and by the need to develop appropriate packaging solutions for wastes that contain carbon-14. Work in this area provides an understanding of the envelope of conditions in which carbon-14 can be managed. The work is integrated with the EC-funded project on the CARbon-14 Source Term (CAST) and with work for the Low Level Waste Repository.



*Reactive metals such as Magnox (left) are a significant source of hydrogen and gaseous carbon-14 following GDF closure, as they corrode upon resaturation of the GDF, as has been investigated experimentally (right)*

### Overview

The gas status report discusses how gas will be managed to ensure safety during transport, operations and after closure of a GDF. It shows how gas generation within waste packages is managed by appropriate controls and procedures when transporting packages and by ensuring adequate ventilation of facilities. It describes how the geological environment influences gas generation and gas migration after closure of a GDF, how the gas may behave in a GDF sited in a range of UK-relevant geological environments and how confidence in safety arguments can be developed. It also identifies knowledge gaps which are addressed in the S&T Plan.

The report outlines RWM's understanding of how gas would be generated in packaged radioactive wastes and how gas migration could subsequently occur through the near field and geosphere. It considers bulk gases and also trace gases, including radioactive species. Gas is considered in the transport, operational and environmental safety cases.

# S&T Programme – Underpinning Knowledge Base MPs

Drivers					
Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	✓
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability	✓				
<p><b>Longer Term Work Requirements</b></p> <p>The nature and extent of site-specific gas migration research will depend on the geology at the site. In all cases, it is likely that there will be a programme of data collection, conceptual model development and modelling to enable future gas migration through the geosphere barrier at the site to be assessed. There may also be a need to carry out experiments to demonstrate understanding of site-specific gas migration through the geosphere. Future research in the two main gas topic areas is expected to include the following:</p> <p><b>(a) Gas Generation and Release from Wasteforms and Waste Packages</b></p> <p>Once one or more sites are under consideration, research will be undertaken to consider gas generation rates as affected by e.g. site-specific water availability and composition. Much of the research to enable this will be undertaken in the package evolution research area, where site-specific understanding based on both the site groundwater chemistry and on the hydrochemistry Site Descriptive Model will be used to refine estimates of metal corrosion rates. Bulk gas generation from the corrosion of metallic wastes and containers will also be influenced by the way in which the GDF is operated, which could impact on water ingress rates during the operational phase. There is, therefore, an interface between the research and design components of the programme in relation to the management of gas.</p> <p>At the site-specific stage there is potential for equivalent site-specific demonstration experiments in underground excavations at the selected site; these demonstration experiments may include studies of gas generation and will build confidence in the understanding of the gas source term and of the subsequent reaction of gas with near-field barriers.</p> <p><b>(b) Gas Migration and Reaction</b></p> <p>RWM has developed its understanding of gas migration through the EBS and the surrounding geosphere by participating in the EC FORGE (<i>Fate Of Repository GasEs</i>) project, which addresses key gas migration issues in GDF performance assessment. Work in FORGE has addressed gas migration through both cement- and clay-based engineered barriers and through clay and fractured rock (though not evaporite) geological environments. RWM is also participating in LASGIT (<i>LA</i>rge-<i>S</i>cale <i>G</i>as <i>I</i>njection <i>T</i>est) at the Äspö underground research laboratory in Sweden. This deposition hole experiment involves gas injection into the centre of a borehole to simulate gas release from a waste container and gas migration through the surrounding bentonite buffer material. Participation in FORGE and LASGIT has provided a strong basis for understanding gas migration. RWM will maintain a watching brief on future similar international projects and may participate in them if they are relevant to RWM’s programme.</p>					

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Radionuclide Behaviour Status Reports (Major Products KB13 & KB14)

Specification

Design

Assessment

Underpinning Knowledge Base

<p><b>Purpose</b></p> <p>To document our understanding of the behaviour of radionuclides within the aqueous pathway across the engineered and natural barriers of the GDF.</p>	 <p><i>RWM's studies include understanding the role of microbes in the retardation or enhanced transportation of radionuclides; for example, metallireducens bacteria can immobilise uranium</i></p> <p><b>Overview</b></p> <p>The radionuclide behaviour status report documents our current understanding of how radionuclides would behave in a GDF and how this affects post-closure safety. It focuses on the groundwater pathway up to, but not including, the biosphere. Radionuclide behaviour in the biosphere and via gas pathways is discussed in separate status reports.</p> <p>The understanding described in the report feeds, in particular, into the Environmental Safety Case and helps to underpin the approach to assess the post-closure safety of the GDF. The focus of this status report is on the safety of the GDF after it has been sealed and closed, so the majority of the text is relevant to radionuclide behaviour in groundwater and how the engineered and natural barriers in a GDF would contain, or delay the release of, radionuclides. The report also explains how radionuclide behaviour is represented in the calculations of post-closure performance that form part of the safety case. It also identifies knowledge gaps which are addressed in the S&amp;T Plan.</p>
<p><b>Information needs and strategic objectives</b></p> <p>It is important to develop an understanding of how radionuclides may be released from the solid wasteforms and gradually move through the engineered and natural barriers in groundwater. In order to demonstrate post-closure safety of a GDF, the quantities of radionuclides which may eventually reach the biosphere need to be shown to be sufficiently low that they will not pose an undue risk to living things.</p> <p>The current generic status report describes the properties of radionuclides that are relevant to the safety of a GDF and presents our understanding of the key processes that affect radionuclide behaviour in, and migration through, the various barriers of a GDF. In the current phase of the work programme, before site-specific information is available, our research addresses radionuclide behaviour in a number of materials that may be used for the engineered barriers of the GDF and in a range of potential host rocks.</p>	
<p><b>Current Work Requirements</b></p> <p>Specific objectives for research into radionuclide behaviours are:</p> <ul style="list-style-type: none"> <li>➤ To understand the release of radionuclides from wasteforms currently used, or under consideration, for HLW/spent fuel and ILW/LLW. This includes consideration of potentially significant processes and perturbing effects (see 'Drivers' below).</li> <li>➤ To understand radionuclide transport through, and immobilisation / retardation in, the engineered barrier system and the geosphere. As above, this includes consideration of potentially significant processes and perturbing effects.</li> <li>➤ To develop justified datasets for radionuclide behaviours for use in assessment models of disposal concepts under consideration.</li> <li>➤ To build more detailed understanding through developing mechanistic models of important processes.</li> </ul> <p>Examples of areas where long-term generic research into radionuclide behaviours may be required are:</p> <ul style="list-style-type: none"> <li>➤ Continuing collaboration in overseas underground research laboratories to develop techniques to obtain site-specific samples (for example, samples containing colloids or microbes) and to develop RWM's understanding of radionuclide behaviour via full-scale or large-scale long-term experiments.</li> <li>➤ Development of thermodynamic databases. For example, if a site with highly saline groundwater is under consideration, research may be needed to develop a Pitzer thermodynamic database.</li> <li>➤ Research to provide more detailed mechanistic understanding of important processes.</li> </ul>	
<p><b>Underpinning Knowledge Base</b></p>	

# S&T Programme – Underpinning Knowledge Base MPs

Drivers					
Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	✓
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability	✓				
Longer Term Work Requirements					
<p>Once one or more sites are under consideration, research activities will involve building site-specific understanding of radionuclide behaviours in the rocks and groundwater surrounding the GDF and along the groundwater pathway back to the biosphere. This will build on RWM’s extensive generic understanding, and it is expected that it will involve laboratory experiments on site-specific materials supported by modelling and by ongoing generic research activities. Demonstration experiments are also likely to be appropriate. In addition, site-specific research will be undertaken to determine radionuclide behaviours in the presence of near-field barrier materials that have evolved through interactions with groundwater at the site. The principal lines of site-specific research are discussed below:</p> <ul style="list-style-type: none"> <li>➤ The largest site-specific research activity will be to undertake a laboratory programme using site-specific rock samples and groundwaters to quantify radionuclide transport, retention and retardation in the geosphere. This will be supported by site-specific geochemical modelling and by ongoing generic research activities to provide mechanistic understanding of the interactions between radionuclides in solution and mineral surfaces. In addition, site-specific coupled modelling may be required. The research programme will determine radionuclide behaviours in both the undisturbed geosphere, distant from the GDF, and in the chemically disturbed zone around the GDF. The research programme will commence during the surface-based stage of site investigation, once sufficient understanding of geology, hydrogeology and hydrochemistry has been obtained from the discipline-based Site Descriptive Models produced by the site characterisation programme.</li> <li>➤ Further to the above, there may also be a requirement to obtain site-specific data for the retention, retardation and degradation of some chemo-toxic compounds. However, a generic understanding may be sufficient.</li> <li>➤ From generic research, RWM understands that there are a number of perturbing factors that have the potential to affect radionuclide behaviours in the geosphere. Two such perturbing factors are naturally-occurring colloidal and microbial populations. These will be sampled and characterised as part of the site characterisation programme. RWM will then undertake site-specific research, including laboratory experiments, to determine the implications of the presence of colloids and microbes on radionuclide speciation, transport and retention / retardation.</li> <li>➤ Naturally-occurring organic matter (for example humic and fulvic acids) also has the potential to affect radionuclide behaviours in the geosphere, through complexation with stable and potentially mobile molecules. This material will be investigated during site characterisation. RWM will then decide whether generic data are sufficient to determine its impact on radionuclide behaviours or whether site-specific research is needed.</li> <li>➤ RWM’s generic research has largely quantified radionuclide transport, retardation and retention in near-field barrier materials. It may be necessary to undertake some site-specific research on radionuclide behaviour.</li> </ul> <p>Having undertaken the site-specific research activities described above, RWM will re-elicite ranges for all parameters required by the assessment models. This re-elicitation will be a major activity and will provide justified representations of radionuclide behaviour for assessment modelling.</p> <p>Finally, long-term laboratory experiments, with timescales up to ~10 years, will be required to demonstrate understanding of radionuclide behaviour. Some will be designed to study a particular process; others will address a range of processes and consider coupling and interactions between processes. These experiments can also provide a link from short-term, laboratory-scale experiments to the long-term, vault-scale processes occurring within the GDF.</p>					

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Waste Package Accident Performance Status Report (Major Product KB15)

Specification

### Purpose

To document RWM’s understanding of how waste packages provide the necessary physical and chemical robustness against fires and impact accidents to support the transport and operational safety cases.

### Information needs and strategic objectives

This report summarises physical tests and computer modelling of waste package accident performance and derives data for use when undertaking safety assessments of waste package transport and handling operations related to a GDF. This understanding has been gained through an extensive programme of R&D activities combined with transferable information from other waste management organisations and research institutions overseas.

This document also includes consideration of information needs that arise from other research drivers, such as the assessment of packaging solutions and identification and development of GDF concepts.

RWM has determined that there are two types of credible accidents, namely impact and fire, or a combination of both. The consequences of an accidental release are set out in the Disposal System Safety Case, and the design targets and limits that RWM works to are defined in its radiological protection policy manual.

### Current Work Requirements

Specific objectives for research into waste package accident performance are:

- To address gaps identified in RWM’s knowledge specific objectives for future waste package accident performance research and development.
- To inform engineering and optioneering decisions on the design of a GDF and waste packages, with the aim of eliminating or reducing potential accident scenarios.
- To develop appropriate methodologies to determine the consequences of specific accident scenarios, including consideration of the accident performance of aged packages.

A significant interdependency exists with the assessment of waste packages for disposability (see Major Product AS13). Parameters derived under the waste package accident performance topic directly inform disposability assessments (e.g. the fraction of a package’s radionuclide content that might be released under accident conditions).

A strategic review of research needs in Waste Package Accident Performance area was completed in November 2012. As part of this, a register of information requests was developed to record the identified research issues identified by various teams within RWM and elsewhere. This was developed through a series of internal and external workshops involving a range of relevant stakeholders and by review of relevant documents. A workshop was held to identify the research priority and urgency of the particular work, in terms of the short to medium term and long term. The resulting forward plan identified work activities for the short to medium term to meet the future needs of the DSSC. Based on this research plan, RWM has commenced a major programme of generic research to address the issues identified.



*Large scale fire accident tests have been conducted previously; the current RWM programme is based on finite element modelling complemented by small-scale radionuclide release tests in a custom developed experimental platform*

### Overview

The generic Waste Package Accident Performance Status Report summarises how waste packages contribute to the safety of the geological disposal system, focusing on their performance during accident conditions. It outlines the safety functions of waste packages (i.e. what they must do), and describes how these are provided through design. RWM’s ability to understand and predict accident performance is presented in summaries of full- and small-scale test work and computer modelling. The report supports the transport and the operational elements of the Disposal System Safety Case.

The report also describes the future work programme identified to address gaps in knowledge associated with our understanding of waste package accident performance under fire, impact and combined fire and impact scenarios

Design

Assessment

Underpinning Knowledge Base

## S&T Programme – Underpinning Knowledge Base MPs

Drivers				
Commercial / Contractual		Cost Impacts		Design Codes & Standards
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification
Environmental Impact & Sustainability		Environmental Safety Case		Flexibility in Decision Making
NDA Strategy		Operational Safety Case	✓	Programme / Risk Management
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case
Waste Package Disposability	✓			
<p><b>Longer Term Work Requirements</b></p> <p>For this research area, it is considered that no site-specific research will be required and a site-specific waste package accident performance status report will therefore also not be needed. The justification for this is as follows:</p> <ul style="list-style-type: none"> <li>➤ Waste package impact accident scenarios are geosphere-specific, because the drop height is dependent on the dimensions of the underground openings (inlet cell, transfer tunnel, disposal vault) through which the waste package is moved. RWM has defined impact accident drop heights for GDFs constructed in a higher strength rock and a lower strength sedimentary rock. Unless the GDF design is changed in the future so that higher drop heights become appropriate, there will be no requirement for site-specific research for potential sites in higher strength rocks or lower strength sedimentary rocks. Further, the drop heights identified for a GDF in a higher strength rock or a lower strength sedimentary rock are considered bounding of a GDF in an evaporite rock environment.</li> <li>➤ Waste package fire accident scenarios are the same for all geological environments. There will, therefore, be no requirement for site-specific research.</li> </ul>				

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Criticality Safety Status Reports (Major Products KB16 & KB17)

Specification

### Purpose

To document RWM’s understanding of how the long-term performance of the GDF can be demonstrated with regards to a hypothetical nuclear criticality event. Both likelihood and consequences of a criticality event are considered.

### Information needs and strategic objectives

Higher activity radioactive wastes contain isotopes of plutonium and uranium. These substances are used, in pure and concentrated forms, as fuel to generate power in nuclear reactors; plutonium is also a by-product of the nuclear fission process. To generate nuclear power, reactors are designed to reach and maintain the condition called criticality - a self-sustaining chain reaction. Uncontrolled criticality however, could under certain circumstances, lead to the release of a significant amount of energy. Criticality safety has been defined as protection against the consequences of an inadvertent nuclear chain reaction, preferably by prevention of the chain reaction.

The criticality safety status report explains the contributions of the multi-barrier system to criticality safety. It presents technical studies that support safety cases for demonstrating criticality safety, and shows how package limits are set to avoid criticality in the short to medium term. It discusses the processes that determine the likelihood of a criticality in the long term. It also summarises understanding of hypothetical post-closure criticalities. RWM assesses criticality safety as part of the transport, operational and environmental safety cases and also as part of advice to site operators on conditioning and packaging proposals.

### Current Work Requirements

Specific objectives for RWM criticality safety R&D are:

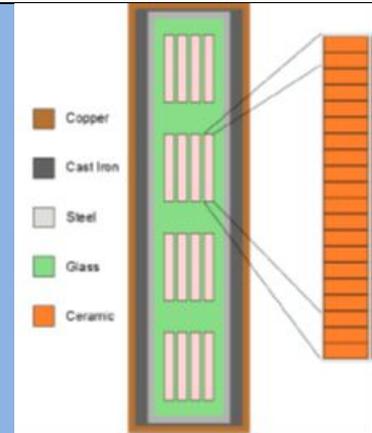
- To demonstrate and ensure sub-criticality in the design of transport and disposal containers for spent fuel, ILW, plutonium and uranium.
- To inform the design, loading and choice of wastefoms and containers in strategic studies for plutonium and uranium that input to Government policy.
- To provide data and understanding on the likelihood of post-closure criticalities for the disposal system safety case, to demonstrate that RWM can ensure criticality safety in a GDF.
- To provide data and understanding on the consequences of hypothetical post-closure criticalities for the disposal system safety case, to demonstrate that RWM can ensure criticality safety in a GDF.

Two projects have recently been completed to address the likelihood and the consequences of a hypothetical criticality event, respectively. The results will be summarised in the 2016 update of the generic criticality safety status report. Based on the results of these projects, RWM has concluded that no further research is required into the generic aspects of the likelihood or consequences of a hypothetical criticality event. Research to support disposability assessments for new packaging proposals and to support new design concepts will continue, since criticality-related research and assessment is required in order to demonstrate and ensure that criticality events do not occur during the transport and operational phases of the GDF lifecycle.

Design

Assessment

Underpinning Knowledge Base



*Recent work by RWM on the likelihood of criticality considered all elements of the entire disposal inventory, including the HEU/Pu package layout for the higher-strength rock disposal concept shown here. The disposal of such highly fissile materials was demonstrated to have a very low likelihood of criticality over a one million year timescale*

### Overview

The criticality safety status report explains the contributions to safety and technical studies that support our safety cases for demonstrating criticality safety. The report is structured to: outline the nature of the wastes and their long-term management requirements; summarise the contributions of disposal system components to safety; show how package limits are set to avoid criticality in the short to medium term; discuss the processes that determine the likelihood of a criticality in the long-term; summarise the understanding of hypothetical post-closure criticalities; and provide a technical summary and conclusion based on the current understanding.

## S&T Programme – Underpinning Knowledge Base MPs

Drivers					
Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	✓
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	✓
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability	✓				
<p><b>Longer Term Work Requirements</b></p> <p>Once site-specific data are available, we may consider refining the treatment of the geosphere in these models. At this stage, RWM may also review the data used to describe the consequences of hypothetical post-closure criticality, to ensure that the data being used are best-suited to the site(s) being considered.</p> <p>Finally, throughout the siting programme, RWM will continue to undertake criticality safety research to support disposability assessments for new packaging proposals and to support new design concepts.</p>					

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Site Characterisation Status Report (Major Product KB18)

Specification

### Purpose

To document RWM’s understanding of the approaches to the design and implementation of information-led investigations for characterisation of potential candidate sites.

### Information needs and strategic objectives

The development of a robust understanding of site characterisation supports the RWM objective to: *“Deliver a focused R&D programme to support geological disposal”*.

This Major Product is aimed at demonstrating that RWM is sufficiently prepared to undertake investigations at candidate sites. The main driver for this work is the Implementing Geological Disposal White Paper, which states that: *“Subsequent, extensive, detailed investigative work would be required to identify and characterise potentially suitable sites to a sufficiently detailed level to support a robust safety case at later stages in the siting process. These investigations would begin with non-intrusive geophysical surveys (which could include aerial and ground-based surveys) to build on the existing understanding of the geology. This understanding will be used to identify locations for the drilling of boreholes, which will test the geophysical interpretations, provide samples for testing (including determination of groundwater composition and age) and allow underground measurements of rock and groundwater properties. Data from these detailed investigations will allow site-specific models to be developed, aided by expertise from the hydrocarbon and mining industries, to predict the long-term geological characteristics of the site.”*

### Current Work Requirements

The delivery of future iterations of this Major Product will require the following activities:

- Keeping a watching brief of developing technologies across a range of relevant sectors through liaison with the supply chain and academic bodies and attendance at relevant conferences.
- Liaising with sister radioactive waste management organisations overseas to keep a watching brief on developing technologies, approaches and lessons learned.
- Developing an approach to sealing deep investigation boreholes in a manner which avoids unnecessary impacts on the safety case for the long-term protection of people and the environment.
- Reviewing the applicability of developing approaches, technologies and lessons learned in other sectors and programmes to the UK programme.
- Publishing updates at appropriate times to capture the results of these reviews.



***In the early stages of site characterisation airborne geophysical surveys such as the British Geological Survey’s Tellus South West Project will provide early data***

### Overview

The site characterisation status report presents a summary of RWM’s understanding of the approaches to the design and implementation of information-led investigations and the work which has been undertaken to demonstrate that we are prepared to implement these investigations in a timely and efficient manner. The updates will address any stakeholder issues and present a summary of the watching brief of new and developing data acquisition, interpretation and modelling technologies across a number of sectors which may be able to meet our future information requirements.

This product facilitates the communication of the understanding of, and readiness for, surface-based investigations to external stakeholders and thereby builds confidence amongst a wider range of stakeholders including communities and Government.

Design

Assessment

Underpinning Knowledge Base

### Drivers

Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development		Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	

## S&T Programme – Underpinning Knowledge Base MPs

NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness	✓	Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability					

Specification

Design

Assessment

Underpinning Knowledge Base

**Longer Term Work Requirements**

The development of detailed site investigation programmes and site characterisation plans during surface-based investigations, construction and underground-based investigations will need to take account of technological developments identified in this Major Product.

A watching brief on data acquisition, interpretation and modelling technologies will need to be maintained throughout surface-based investigations and into the early parts of the construction and underground-based investigations phase so that RWM has the capability to investigate another site if the candidate site(s) being investigated prove to be unsuitable, or so as to apply the most appropriate characterisation techniques available at that time.

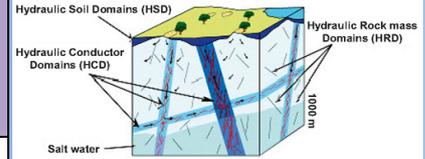
# S&T Programme – Underpinning Knowledge Base MPs

## Development of a Conceptual Understanding of the Geosphere (Major Product KB19)

Specification

### Purpose

To develop sufficient understanding of the geoscientific properties of potential candidate sites so as to compare their suitability for hosting a GDF.



**A 3D schematic of SKB's conceptual understanding of the Forsmark site**

### Overview

A geoscientific conceptual understanding is an integrated description and/or a model of the geoscientific aspects of a potential area or site. This will allow RWM to compare the suitability of competing candidate areas or sites and meet the information requirements needed as an input to the disposal systems specification, the engineering design and the environmental safety case. A conceptual understanding describes and/or models the various facets of a site.

The principal rationale for a conceptual understanding is to provide RWM and stakeholders at any phase in the site characterisation process with a robust product (written, visual, annotated, animated), which assists and is driven by the disposal system specification, the engineering design and the environmental safety case.

Design

### Information needs and strategic objectives

The development of a conceptual understanding supports RWMs objective to: *“Deliver a focused R&D programme to support geological disposal”*.

In the early stages of site selection, the conceptual understanding will comprise the understanding necessary to support the consideration of areas to identify and assess potential candidate sites. In the later stages of the process the conceptual understanding will take the form of Site Descriptive Models (SDM), which gradually build the understanding to a level sufficient to support a safety case for a specific site. The conceptual understanding will be underpinned by factual data, modelling and interpretative reports.

### Current Work Requirements

The preparation for surface-based investigations project comprises the planning, design and specification of the geoscientific activities that will be required to support the various stages of the site selection process.

Two key objectives of the project are to:

- Maintain and develop understanding of approaches to the design and implementation of information-led investigations (surface-based and underground investigations) and input this knowledge and understanding into discussions with key stakeholders, as necessary; and
- Undertake sufficient work such that the desk-based studies and site investigations can be implemented in a timely and efficient manner.

Development of the required conceptual understanding will involve interpretation and modelling of the data acquired at all stages of site investigations and integration across the following disciplines: geology, hydrogeology, hydrochemistry, rock mechanics / geotechnical, thermally driven processes, radionuclide transport, biosphere impacts.

Assessment

### Drivers

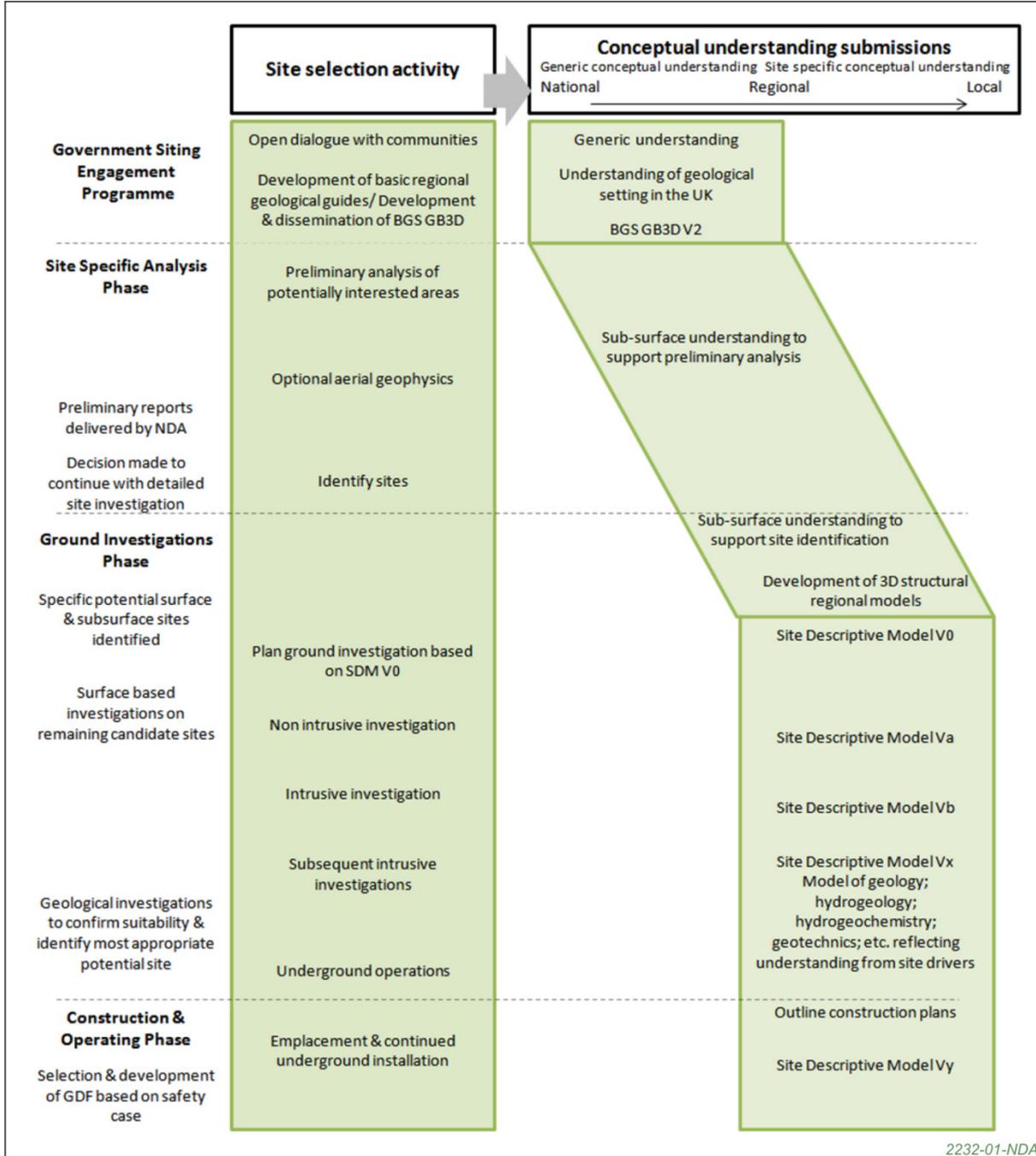
Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development		Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness	✓	Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability					

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Longer Term Work Requirements

The strategy for developing and updating the conceptual understanding of the geosphere, as it evolves from an understanding necessary to support the early siting process to a Site Descriptive Model to support an engineering design and safety case for a specific site, is summarised in the figure below.



### The strategy for developing and updating the conceptual understanding of the geosphere

In the early stages of the siting process, aerial geophysical surveys (gravity, magnetic, electromagnetic and radiometrics) are available to collect additional geological data over significant geographical areas in a cost effective manner to support existing data. The magnetic, electromagnetic and gravity methods use sensors on board an aircraft which measure variations in the Earth’s magnetic and gravity field as a result of rocks in the subsurface. Radiometric surveys measure the naturally occurring radioactivity in rocks. Together these methods enable geologists to characterise different rock types and make it possible to pick out large-scale geological features such as faults.

Specification

Design

Assessment

Underpinning Knowledge Base

## S&T Programme – Underpinning Knowledge Base MPs

Specification

Land-based non-intrusive investigation techniques include surface geological mapping, surveying of surface and near-surface water features such as rivers and aquifers, and further geophysical investigations. Land-based geophysical investigations are likely to be dominated by seismic techniques which involve analysing the sub-surface from the way in which it reflects and refracts sonic stimuli generated at the surface. These techniques can provide considerable understanding of the broad structure of the sub-surface including the depths to particular layers and the location of large and medium scale faults.

Intrusive borehole investigations will allow the collection of rock and groundwater samples to establish the subsurface geology and hydrochemistry. Laboratory testing of the samples will provide quantitative information for the full range of physical and chemical properties. The boreholes will also enable in situ measurements of the physical, mechanical and hydraulic properties of the different rock types present to the full depth of the borehole at a scale much greater than that achievable in the laboratory. The boreholes can also be instrumented to establish a hydrogeological monitoring network once testing in each borehole is complete. The data and results will be interpreted and used to develop numerical models which will underpin the Site Descriptive Model (SDM).

Design

The conceptual understanding will interpret the data from subsequent drilling campaigns and further non-intrusive investigations to identify the most suitable site for a GDF and facilitate development of the safety case. Assuming the conceptual understanding demonstrates a sufficient level of confidence a post-completion testing programme will be established to carry out multi-hole hydrogeological testing. Once this testing and monitoring is complete a set of baseline conditions should be met to fulfil the requirements of the Disposal System Specification, the engineering design and the environmental safety case before moving into the constructing and operating phase. The conceptual understanding will continue to be enhanced and used to assist planning throughout construction.

Throughout this process the following key issues will need to be addressed:

Assessment

- In order to identify potential geological settings and potential volumes of suitable host rock within those settings, potential host rock attributes need to be considered in conjunction with the characteristics of the cover rocks.
- An appropriate approach to allow decisions to be made in the context of the geoscientific uncertainty at different stages in the development of the conceptual understanding will need to be defined, which is consistent with RWM's wider approach to uncertainty. In the early stages this is likely to involve a more qualitative approach which identifies the alternative concepts which are consistent with the available data. As more data is collected to address the key knowledge gaps, a more quantitative approach is likely to evolve to provide robust numerical underpinning of the later SDMs focusing on the alternatives which are material to the safety case.
- The timing and nature of the move to quantitative modelling to support the SDM will be closely linked to the conceptual uncertainty. Decisions on the balance between stochastic and deterministic approaches will need to be made on a site specific basis taking into account factors such as the importance of fault and fracture flow to the safety case.
- In order to decide when the surface-based investigations are complete and the SDM is sufficient to support a decision to go underground, clear criteria for the end of surface-based investigations will need to be defined. The proposed criteria for establishing completion of the phase of surface-based investigations are likely to be of the following nature:
  - Provision of data and information to meet defined information requirements.
  - Completion of a defined programme of model preparation and testing.
  - Meeting user requirements in relation to Environmental Safety Case and engineering design.

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Site Characterisation Programme (Major Product KB20)

### Purpose

To develop a generic programme capturing the logic links between likely activities during RWM’s surface-based investigations phase at sufficient detail to support the development of site-specific site characterisation programmes for potential sites during the planned and transitional activities of RWM’s preparatory studies phase. The programme would also consider the underground investigations.

### Information needs and strategic objectives

Development of a Site Characterisation Programme address RWM’s strategic objective to ‘*deliver a focused R&D programme to support geological disposal*’ and in particular ‘*to develop a needs-driven site characterisation programme.*’ The main driver for this work is the Implementing Geological Disposal White Paper, as detailed for Major Product KB18.

The development of a generic site characterisation programme is intended to demonstrate that RWM is sufficiently prepared to undertake investigations at candidate sites.

The approach would initially involve the identification of the specific information requirements needed to support the site-specific disposal system specification, engineering design and safety assessments. An integrated programme of non-intrusive and intrusive surface-based investigations capable of providing the data and subsequent understanding will then be developed. The programme would also consider the underground investigations.

The existing strategy for the geoscientific aspects of site characterisation [1] may need to be updated during the planned and transitional activities of RWM’s Preparatory Studies Phase to take into account lessons learnt during this stage of the process or from other sources such as sister organisations or other sectors. It is likely to evolve during the Surface-based Investigations Phase, to more clearly define the strategy for site characterisation during the construction and underground-based investigations phase.



Site characterisation will include surface-based investigations

### Overview

The ultimate objective of site characterisation is to provide the information needed for development of the facility design, safety case and environmental assessments. This assessment of suitability is to ensure that disposal activities are carried out in such a way that protects the health and interests of people and the integrity of the environment, at the time of disposal and in the future.

Continued participation in overseas underground research laboratory (URL) activities will allow RWM to maintain and improve its knowledge of the influence on GDF performance of a range of relevant geological properties, thereby allowing adaptation of the site characterisation strategy, as appropriate, to ensure that necessary information on the site-specific geosphere is obtained in the most efficient and cost-effective manner.

Specification

Design

Assessment

Underpinning Knowledge Base

### Drivers

Commercial / Contractual		Cost Impacts		Design Codes & Standards	
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	
NDA Strategy	✓	Operational Safety Case	✓	Programme / Risk Management	✓
QA / Data Robustness		Regulatory Requirements		Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results	✓	Siting Process (Voluntarism)	✓
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	

# S&T Programme – Underpinning Knowledge Base MPs

Specification

## Current Work Requirements

The development of detailed site investigation programmes, site characterisation plans, surface-based investigations and underground investigations will all benefit from the understanding developed in the delivery of an initial generic site characterisation programme. Work will need to be undertaken to:

- Identify the range of site investigation activities needed to meet the information requirements for design and assessments.
- Generate a detailed generic programme(s) incorporating the full range of activities taking into account the high level programmes generated from the Preparing for Integration during RWM’s Surface-based Investigations Phase work package, the detailed drilling and testing programmes developed to support the GDF Implementation Plan (Major Product DE12) and RWM’s developing understanding of underground investigations from involvement in overseas facilities.
- Peer review the programme.

This work will be led by RWM’s ‘Geological Investigations Manager’ directed by the Head of Site Characterisation and supported by the supply chain.

Design

## Longer Term Work Requirements

The development of a site-specific site characterisation programme will take into account the lessons learnt from the development of the generic programme. It is important to note however that it would not be produced through the further development of the generic programme *per se*. The approach would initially involve the identification of the specific information requirements needed to support the site-specific disposal system specification, engineering design and safety assessments. An integrated programme of non-intrusive and intrusive surface-based and underground investigations capable of providing the data and subsequent understanding will then be developed.

## References

[1] NDA, Geological Disposal: *Proposed Strategy for the Geoscientific Aspects of Site Characterisation*, NDA Report No. NDA/RWM/017, March 2011.

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Management System for Geoscientific Data (Major Product KB21)

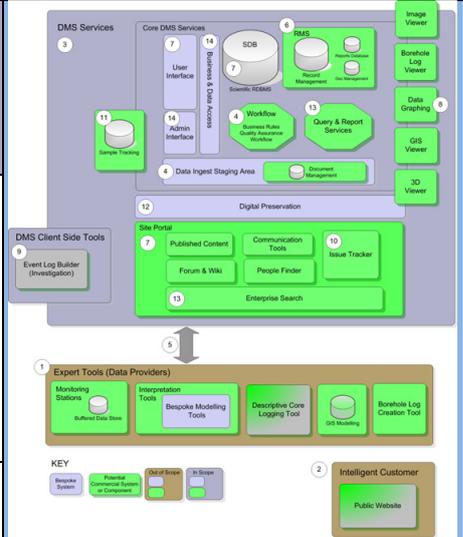
**Purpose**  
 To provide a robust and defensible audit trail from the data through the conceptual understanding of the site to the design and assessment Major Products.

**Information needs and strategic objectives**  
 This Major Product supports the RWM objective to: *“Deliver a focused R&D programme to support geological disposal”*.  
 The management system for geoscientific data will ensure that the data collected during RWM’s surface-based investigations are captured and recorded in a manner which is robust and defensible in accordance with the Environment Agency’s guidance [1].

**Current Work Requirements**  
 Considerable work has been undertaken to define the generic operational requirements that a data management system must meet. However, given that the specification for the Data Management System will be performance-driven, RWM will not prescribe activities to be undertaken during the construction of a DMS, although they are likely to include the following:

- Finalisation of performance specification.
- Detailed architectural design.
- Construction / assembly of components.
- System testing / commissioning.

**Longer Term Work Requirements**  
 It is likely that the DMS procured for and operated during RWM’s Surface-based Investigations Phase will need to be replaced with a state-of-the-art system during the early part of the construction and underground-based investigations, due to the long duration of the surface-based investigations and the anticipated continual rapid development of computing hardware and software.



**The Data Management System will comprise a number of interoperable components**

**Overview**  
 This Major Product comprises a fully commissioned and functioning Data Management System (DMS) to be available prior to the collection of any site characterisation information. This is needed to provide a robust and defensible audit trail from the data through the conceptual understanding of the site to the design and assessment major products.

Drivers					
Disposal Concept Development		Disposal System Design	✓	Disposal System Specification	✓
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	✓
NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness	✓	Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	✓
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability					

**References**  
 [1] Environment Agency, *Geological Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation*, February 2009.

Specification

Design

Assessment

Underpinning Knowledge Base

# S&T Programme – Underpinning Knowledge Base MPs

## Initial Site Evaluations (Major Product KB22)

Specification

Design

Assessment

Underpinning Knowledge Base

<p><b>Purpose</b></p> <p>To meet the Environment Agency requirement for an Initial Site Evaluation in support of the application for an environmental permit to start intrusive investigations at a candidate site for a GDF.</p>																			
<p><b>Information needs and strategic objectives</b></p> <p>The development of an Initial Site Evaluation (ISE) supports RWM’s objective to: <i>“Develop the specification, design, safety case and environmental and sustainability assessments for the disposal system and obtaining regulatory support”</i>.</p> <p>It also supports the maintenance of a clear and responsive approach to engagement with regulators.</p>																			
<p><b>Current Work Requirements</b></p> <p>The ISE will be underpinned by the conceptual understanding and Site Descriptive Models as surface-based Investigations proceed. The first ISE will be submitted prior to the commencement of intrusive investigations at the beginning of RWM’s surface-based investigations.</p> <p>Further to the GRA document (see Drivers, below) the Environment Agency has shared its draft ‘ISE Advice to Reviewers’ with RWM. This document provides further details on its expectations, including that it will:</p> <ul style="list-style-type: none"> <li>➤ Summarise the technical reasons for selection of the candidate site addressed in an ISE and describe the proposed site characterisation programme, its overall objectives and its success criteria.</li> <li>➤ Explain how information derived from desk-based studies and from any non-intrusive investigation work, such as geophysical surveys, has been used to build an understanding of a candidate site and to identify locations for intrusive investigation work.</li> <li>➤ Explain how information and data from each of the boreholes initially identified is expected to increase conceptual understanding of the site and how this might be used to inform an assessment of the feasibility of developing a GDF at the candidate site.</li> <li>➤ Explain how the borehole(s) can be subsequently sealed in a manner that provides appropriate environmental protection.</li> </ul>																			
<p><b>Longer Term Work Requirements</b></p> <p>Throughout the site investigations phase revisions to the ISE will be required to enable the Environment Agency to issue revised environmental permits for new intrusive investigations as and when they are required.</p>	<p><i>Current RWM research on sealing site investigation boreholes is drawing on work undertaken by other waste management organisations and by the oil and gas industry. The figure shows a borehole sealing study supported by Scandinavian waste management organisations, which are investigating the use of a bentonite filled, perforated copper cylinder for sealing of boreholes; upon hydration the bentonite will swell through the holes, preventing the borehole becoming a means of ‘short-circuiting’ the geosphere migration barrier. This concept is one of several now being considered in RWM work</i></p> <p><b>Overview</b></p> <p>The Initial Site Evaluation (ISE) is required to provide largely qualitative views on the feasibility of constructing a geological disposal facility at the candidate site and whether such a facility might meet the principles and requirements set out in regulatory guidance. The regulator will also need to understand from the initial site evaluation how RWM might develop the ESC for such a facility.</p> <p>Objectives of the ISE also include the identification of the intrusive investigations that may be required to adequately characterise the candidate site(s), and the manner in which they would be designed and implemented in order to appropriately mitigate any adverse impacts.</p>																		
<p><b>Drivers</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Commercial / Contractual</td> <td style="width: 10%;"></td> <td style="width: 33%;">Cost Impacts</td> <td style="width: 10%;"></td> <td style="width: 14%;">Design Codes &amp; Standards</td> <td style="width: 10%;"></td> </tr> <tr> <td>Disposal Concept Development</td> <td style="text-align: center;">✓</td> <td>Disposal System Design</td> <td style="text-align: center;">✓</td> <td>Disposal System Specification</td> <td style="text-align: center;">✓</td> </tr> <tr> <td>Environmental Impact &amp; Sustainability</td> <td></td> <td>Environmental Safety Case</td> <td style="text-align: center;">✓</td> <td>Flexibility in Decision Making</td> <td style="text-align: center;">✓</td> </tr> </table>		Commercial / Contractual		Cost Impacts		Design Codes & Standards		Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓	Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	✓
Commercial / Contractual		Cost Impacts		Design Codes & Standards															
Disposal Concept Development	✓	Disposal System Design	✓	Disposal System Specification	✓														
Environmental Impact & Sustainability		Environmental Safety Case	✓	Flexibility in Decision Making	✓														

## S&T Programme – Underpinning Knowledge Base MPs

NDA Strategy		Operational Safety Case		Programme / Risk Management	
QA / Data Robustness		Regulatory Requirements	✓	Safety Case Methodology	
Site Assessment / Permissioning	✓	Site Characterisation Results		Siting Process (Voluntarism)	
Socioeconomic Impacts		Stakeholder Engagement	✓	Transport Safety Case	
Waste Package Disposability	✓				

Specification

Design

Assessment

Underpinning Knowledge Base

**Notes:** The EA’s Guidance on Requirements for Authorisation [1] states the following:

*“Initial site evaluation – At the hold point before an intrusive site investigation programme begins, we would expect an ‘initial site evaluation’, giving largely qualitative views on the feasibility of constructing a geological disposal facility at the potential site and whether such a facility might meet the principles and requirements of this guidance. We shall need to understand from the initial site evaluation how the developer might construct the environmental safety case for such a facility.*

*If the developer has made an acceptable application and submitted a suitable initial site evaluation then we could grant an environmental permit to proceed with site investigation subject to any conditions or limits that might be imposed. The developer could then proceed with site investigation including borehole studies to investigate the geological formation at the selected site or sites.*

*At this stage, our regulatory aim will be to ensure that any proposed intrusive site investigation will not compromise the integrity of a candidate site to the unacceptable detriment of the long-term environmental safety case for a possible geological disposal facility. We shall also want to ensure the adequacy of a developer’s proposals for collecting information and data to support a decision to start underground operations.”*

**References**

[1] Environment Agency, *Geological Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation*, February 2009.

## 8 References

- 1 Nuclear Decommissioning Authority and Department of Energy and Climate Change, *Radioactive Wastes in the UK: A Summary of the 2013 Inventory*, URN 14D039, NDA/ST/STY (14) 0006, February 2014.
- 2 Department of Energy and Climate Change, *Implementing Geological Disposal: A Framework for the long-term management of higher activity radioactive waste*, URN 14D/235, July 2014.
- 3 Radioactive Waste Management Limited, *A safer future by managing radioactive waste effectively, to protect people and the environment, Corporate Strategy 2015-2018*, May 2015.
- 4 Radioactive Waste Management Limited, *Geological Disposal: Science and Technology Plan*, NDA/RWM/121, Version 2, 2015.
- 5 Nuclear Decommissioning Authority, *Geological Disposal: A Public and Stakeholder Engagement and Communications Strategy*, NDA Report no. NDA/RWM/015, 2009.
- 6 Nuclear Decommissioning Authority, *Geological Disposal: An overview of the Generic Disposal System Safety Case*, NDA Report no. NDA/RWM/010, December 2010.
- 7 Nuclear Decommissioning Authority, *Geological Disposal: RWMD Approach to Issues Management*, NDA Report NDA/RWM/081, Version 3, March 2013.



Certificate No LRQ 4008580

**Radioactive Waste Management Limited**  
Building 587  
Curie Avenue  
Harwell Oxford  
Didcot  
Oxfordshire OX11 0RH

**t** +44 (0)1925 802820

**f** +44 (0)1925 802932

**w** [www.nda.gov.uk/rwm](http://www.nda.gov.uk/rwm)

© Nuclear Decommissioning Authority 2016