

Geological Disposal

Steps towards implementation

Executive summary

March 2010





Our Radioactive Waste Management Directorate (RWMD) is responsible for managing the delivery of geological disposal for higher activity radioactive wastes, as required under UK Government policy. This policy also states that the siting of a geological disposal facility will be based on a voluntarism and partnership approach.

In this summary of our published report (Geological Disposal – Steps towards implementation) we describe the preparatory work that we have undertaken so far, including the planning of our future work programme and the management arrangements to deliver it. This report is intended to provide information to a wide range of interested parties on the steps we believe will be required for successful implementation of geological disposal. It will also explain how the various activities and outputs of our work programme are designed to achieve a safe, secure, sustainable and publicly acceptable outcome.

As the development of the implementation programme is at an early stage there are inevitably many uncertainties; these are outlined in the report and explanations given of how they are accommodated in our planning. It will be some time before a site is selected, but while this is happening we need to develop plans, with the support of others, as to how we ultimately will deal with the waste and get it safely underground.

In this report, we consider what we currently know or those things we currently assume which are important in planning the development of a geological disposal facility, including in particular:

- the amount of radioactive waste requiring geological disposal;
- the types of rock that potentially could host a facility; and
- the potential geological disposal concepts.

Low level waste



Intermediate level waste



High level waste



The radioactive waste

Our first consideration is the amount of waste that needs disposal. The Managing Radioactive Waste Safely (MRWS) White Paper sets out what is known as the Baseline Inventory of the higher activity radioactive waste that is a legacy from nuclear activities that have been undertaken or committed to up to now. This includes radioactive materials which have not yet been classified as waste, such as spent nuclear fuel from power stations which has not been reprocessed; plutonium and uranium extracted from spent fuel that has been reprocessed; and uranium from the nuclear fuel manufacturing process.

A programme to build new nuclear power stations would produce more waste for disposal. The Government believes it is technically possible and desirable to dispose of both new and legacy wastes in the same geological disposal facilities. We have carried out technical assessments of the disposability of the new wastes that would be produced that support this view.

Baseline Inventory

Materials	Notes	Packaged volume		Radioactivity (At 1 April 2040)	
		Cubic Metres	%	Terabequerels	%
HLW	1,2,3,5	1,400	0.3	36,000,000	41.3
ILW	1,2,5	364,000	76.3	2,200,000	2.5
LLW (not for LLWR)	1,2,5	17,000	3.6	<100	0
Spent nuclear fuel	1,4,5	11,200	2.3	45,000,000	51.6
Plutonium	1,4,5	3,300	0.7	4,000,000	4.6
Uranium	1,4,5	80,000	16.8	3,000	0
Total		476,900	100	87,200,000	100

The geology

Based on the research that we and others have undertaken in the past three decades or so, we believe that there is geology in the UK that is suitable to host a geological disposal facility. For our preparatory work we have considered three broad (generic) host-rock types. This helps us explore potential conceptual designs for a facility in any of these rock types.

These are:

- **Higher strength rocks:** These rocks, for example granite, themselves generally have a very low permeability to water flow so that any water flow that does occur is in open cracks, or fractures, that have formed in the rock mass. This type of rock is planned to be used in Finland and Sweden at the sites chosen for their geological disposal facilities for spent nuclear fuel.
- **Lower strength sedimentary rocks:** These rocks are generally physically uniform and any flow of water occurs through the overall rock mass. The Swiss Opalinus Clay geological disposal concept is designed for this type of rock.
- **Evaporites:** These rocks, for example rock salt, may contain water that has been trapped within them ever since they were formed, but they are isolated from water flow that could dissolve them. In the USA this type of rock is used for the Waste Isolation Pilot Plant, where waste has been disposed of for more than a decade, in New Mexico; Germany has also developed a concept for this type of rock.

Illustrative disposal concept examples

Host Rock	Illustrative Geological Disposal Concept Examples	
	ILW/LLW	HLW/SF
Higher strength rocks	UK (Geological Disposal Concept for ILW/LLW, NDA)	Sweden (KBS-3V, SKB)
Lower strength sedimentary rock	Switzerland (Opalinus Clay, Nagra)	Switzerland (Opalinus Clay, Nagra)
Evaporites	United States (WIPP, US DoE)	Germany (Salt dome, DBE Technology)

Multi-barrier approach to geological disposal

A range of generic geological disposal concepts is available that can provide safe and secure geological disposal of higher activity wastes for each of the potentially suitable UK geological settings identified above. Typically a different range of disposal concepts needs to be considered in relation to different geological settings. However, each concept will utilise a ‘multi barrier’ approach.

This approach involves engineered and natural barriers working together to prevent radioactivity being released to the surface in amounts that could cause harm to life and the environment. It works as follows:

- **The waste form:** This is the form into which the waste is conditioned to make it suitable for disposal. This form might be chosen so that it is very resistant to the leaching of radionuclides by groundwater, as in the example of converting high-level waste into a glass waste form.
- **The waste container:** The conditioned waste is placed in a container, creating what is referred to as the waste package. The container is constructed to have sufficient strength and corrosion resistance that the waste will be safely contained during its initial, interim storage and its eventual transport to the geological disposal facility and transfer underground. The material and design of the container can be chosen to subsequently provide reliable physical containment under disposal conditions for extended periods of time.
- **The buffer or backfill:** When waste packages have been placed underground in a disposal facility, at an appropriate stage according to the design and taking account of societal considerations of retrievability, they will be surrounded with buffer or backfill materials. In addition to providing physical support for the waste packages, the buffer or backfill can be designed to provide qualities such as physical and/or chemical protection of the waste container, and physical and/or chemical controls on the migration of radionuclides away from the waste packages.
- **Mass backfill:** In addition to the buffer or backfill around the waste containers, all access tunnels and shafts will be filled in with mass backfill, prior to closure of the facility. The mass backfill might simply be required to ensure other engineered barriers are retained in place but could also be designed to control groundwater flow.
- **Sealing systems:** Engineered seals will be used to prevent the flow of fluids in the excavated tunnels. Seals may also be used where appropriate on parts of the rock that are more permeable.

- Geology:** The rock formations themselves will act as a barrier in a number of ways that could include limiting the flow of groundwater or of any gas released from the waste packages, limiting the movement of radionuclides towards the ground surface, and protecting the wastes deep underground from extreme changes (human or natural) that may take place on the Earth's surface.

A multi barrier approach for intermediate level waste

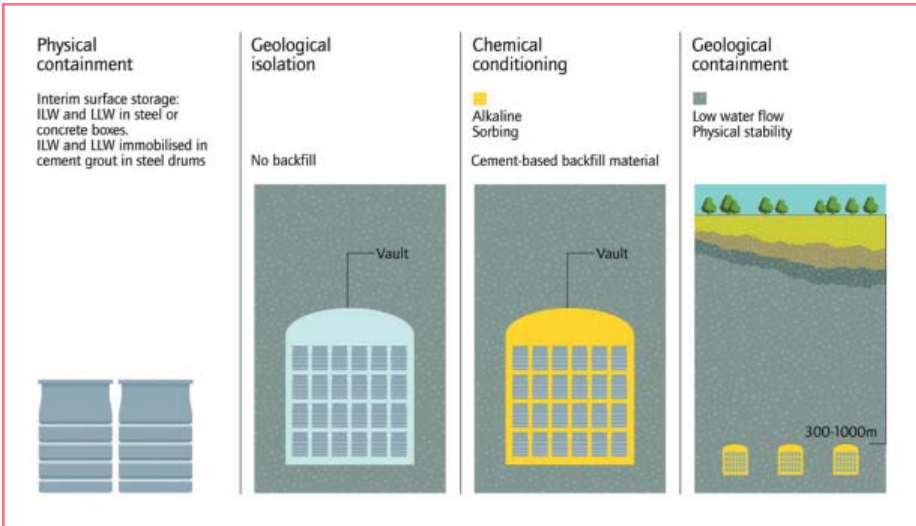
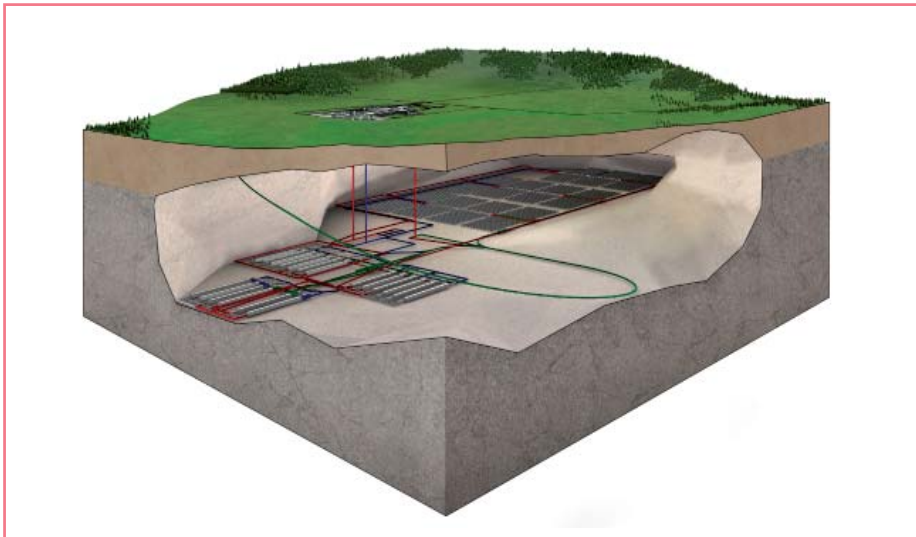


Illustration of a geological disposal facility



Phases of work in our programme for implementing a geological disposal facility

We have defined a number of phases in our programme of work for successful implementation of a geological disposal facility that run from its initial planning through to its closure and beyond. The earlier phases are aligned to the stages of the site selection process set out in the UK Government's MRWS White Paper.

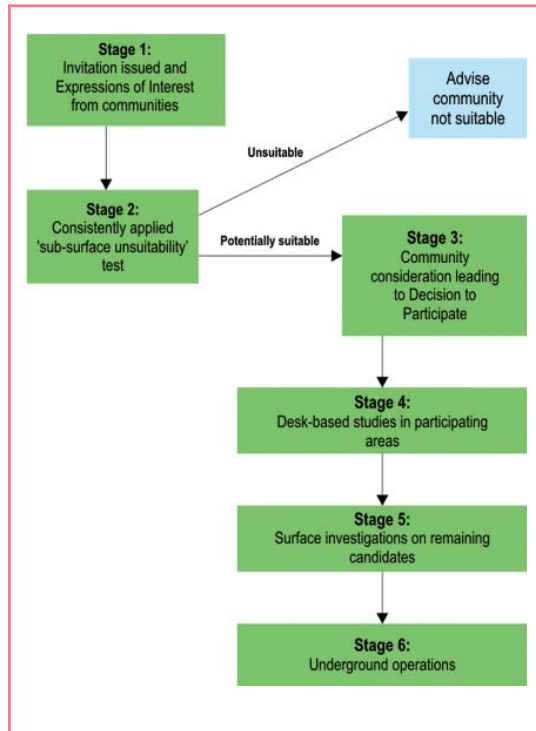
- **Preparatory Studies Phase**

This is the current phase of our work and it coincides with the UK Government's MRWS Stages 1 to 4 of the site selection process. Purely as a planning assumption we assume that this phase will be about five years in duration. Our work supports the UK Government and communities who have expressed an interest in participating in the site selection process. We are developing conceptual facility designs and the safety and environmental assessments for those designs. Areas deemed unsuitable following screening by the British Geological Survey will be ruled out during this phase. Communities with potentially suitable sites may opt to move to a decision to participate in the site selection process although they will continue to have a right of withdrawal until construction is about to begin, just before the construction and underground investigations stage. On behalf of the UK Government, we will work with the communities who take a decision to participate to undertake desk-based studies of any candidate sites identified in their areas. The studies will inform decisions about proceeding to the next stage in the site selection process.

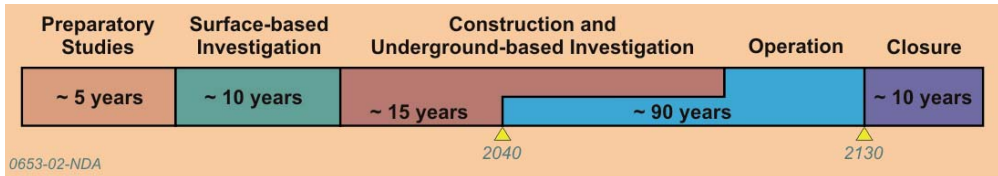
- **Surface Based Investigations Phase**

This phase of our work coincides with the UK Government's MRWS Stage 5 of the site selection process. If communities decide to proceed, the UK Government will agree candidate sites for surface-based investigations.

MRWS site selection process



Geological Disposal Programme timeline indicating phases



At this time we will need to obtain the necessary environmental permits and planning permission to carry out borehole drilling to investigate the geology more closely. A monitoring programme for the geology during the entire life of the project will also be established at this time. We currently assume this phase will take about ten years to complete and ultimately will help inform UK Government’s decision on a preferred site. We will work closely during this phase with the Community Siting Partnership that the UK Government expects will be set up in communities who take a decision to participate.

- Construction and Underground Based Investigations Phase**

This phase will begin once the UK Government has decided on a preferred site in accordance with the MRWS process. This phase of our work coincides with the beginning of UK Government’s MRWS Stage 6 of the site selection process. For planning purposes we assume that this decision could be made around 2025 and is fully dependant on the outcome of discussions between the UK Government and the local community. Following this, we will seek planning and regulatory permissions. Procurement and contractual arrangements for construction of the facility will be finalised. We will undertake long-term investigations from underground to confirm the site is suitable. We will work closely with the regulators and once planning permission is given, construction and investigations from underground will begin. Tunnels and vaults for the waste will be excavated and surface facilities built. If UK Government and the regulators have been satisfied that the programme should proceed following the underground-based investigations, the required permissions and authorisations will be sought to operate the disposal facility. We currently assume that this phase will take about 15 years to complete.

- Operation Phase**

For planning purposes this phase is assumed to begin around 2040. It would continue until all the waste designated for disposal in the facility had been placed underground, assuming that the UK Government and regulators remained satisfied with the safety of the disposal facility and in particular that it would provide a sufficient level of containment. There will be a rigorous system of checking all waste packages sent to the facility for disposal. The system for transporting radioactive wastes from the sites where it is stored

to the disposal facility will be developed to minimise potential environmental impacts and will be designed to operate in a safe and efficient manner.

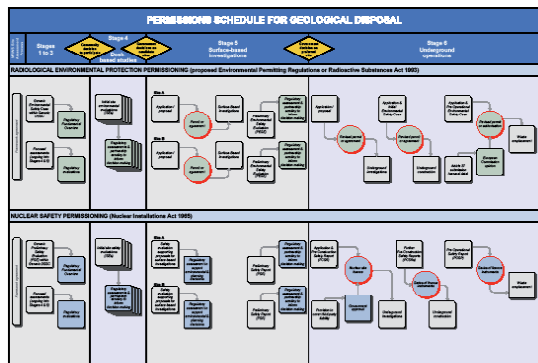
- **Closure Phase**

The decision on when to close the facility after all of the waste has been placed underground for final disposal will take into consideration the views of the local community. Leading up to closure of the underground facilities, disposal vaults and deposition tunnels will have been backfilled, the underground openings sealed and the access ways backfilled and closed. It is anticipated this step will take about ten years. Records from the geological disposal facility will be placed in a national archive and any permanent marking for the site will be agreed by the UK Government, the regulators and the local community. A period of post-closure monitoring could be undertaken by the authority responsible for institutional control of the site.

Schedule for gaining permissions

We are working with the UK Government and regulators to develop a schedule that is consistent with the policy commitments set out in the MRWS White Paper. Currently the schedule describes the proposed process that we plan to follow when the time comes to seek the required permissions, rather than being a timetable for such applications to be submitted.

Permissions Schedule



Engaging and communicating with the public and stakeholders



We cannot do this alone. The implementation of the geological disposal programme will proceed in partnership with other organisations. Amongst the most important of these are UK Government, local decision making bodies, Community Siting Partnership, regulatory bodies and current and prospective waste producers.

Our work involves sharing information and learning through feedback we receive from others. Following consultations, we have developed and published a public and stakeholder engagement strategy that outlines the aims and objectives of the strategy and how we propose to engage and communicate with stakeholders about our work programme on geological disposal.

Costs

The current estimate of the NDA's share of the cost for the geological disposal programme for currently identified wastes and spent fuel is £3.7 billion using the UK Government's discounting method, or about £12 billion without discounting. We have estimated a further cost of about £2 billion, without discounting, for the inclusion of existing stocks of separated plutonium and uranium if it were required to dispose of these materials.



Certificate No 4002929



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Nuclear Decommissioning Authority
Radioactive Waste Management Directorate
Building 587
Curie Avenue
Harwell Science and Innovation Campus
Didcot
Oxfordshire OX11 0RH

ISBN 978 1 84029 402 6

t +44 (0)1925 802820

f +44 (0)1925 802932

w www.nda.gov.uk

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