Dounreay
Decommissioning excellence

Title: Managing Low Level Waste at Dounreay	**Abstract:** #16269 **Session:** 3.6 **Date issued:** 15 January 2016
Purpose: Waste Management Conference	

Author	**Author/Sponsor**
Marie Mackay Community Relations Coordinator, DSRL	Bruce Covert Project Director Waste, DSRL
Signature: Marie S Mackay.	*Signature:* Bruce Covert
Date: 11.1.16	*Date:* 15/1/16

Managing Low-Level Waste at Dounreay

Marie Mackay & Bruce Covert
Dounreay Site Restoration Ltd

ABSTRACT

Overview
Dounreay Site Restoration Limited (DSRL) is the site licence company responsible for the clean-up and demolition of Britain's former centre of fast reactor research and development.

Our aim is to become the benchmark in Europe for successful decommissioning of a complex nuclear site.

DSRL holds the site licence under the Nuclear Installations Act, the waste disposal authorisation under the Radioactive Substances Act and other necessary legal permits for managing the site closure programme.

DSRL operates under contract to the Nuclear Decommissioning Authority (NDA), a non-departmental public body of the UK Government that owns the site.

DSRL is a wholly-owned subsidiary of the Cavendish Dounreay Partnership Ltd, a consortium of AECOM, Cavendish Nuclear and CH2M. It is funded by the NDA to deliver the site closure programme agreed with the Cavendish Dounreay Partnership.

The Dounreay site requires facilities to dispose of up to 175,000 cubic metres of low level waste (LLW) that has been and will continue to be generated during the decommissioning and restoration of the site. In May 2014, construction of two new vaults for the disposal of LLW at Dounreay was completed, including the necessary roads, infrastructures and services, followed by an encapsulation plant in September 2014. The vaults are located immediately to the northeast of the Dounreay licensed site, on NDA-owned land. The facilities are for disposal of the solid LLW generated at Dounreay and the adjacent Vulcan site only.

How did DSRL come to the decision to construct these facilities?
In 2004, following consultation with stakeholders and members of the public, Dounreay issued the “Best Practicable Environmental Option (BPEO) Report” on the management of Dounreay LLW. This report assessed potential management options for LLW against a range of criteria, including technical, environmental, cost, health and safety issues.

The study was conducted in line with best practice and involved consultation with a range of people, including the local community and organisations with an interest in radioactive waste management. The recommendations and conclusions from the study provided the basis for the “Dounreay Solid LLW Overall Strategy”, which was published in March 2005. A fundamental component of this strategy was the

development of new below-ground disposal vaults for LLW at Dounreay. Siting the vaults on land at Dounreay avoids any need to transport the LLW away from Dounreay on public roads. Disposal at Dounreay therefore satisfies the proximity principle of managing the waste at source. Disposal at Dounreay is also consistent with UK Government Policy on LLW management, the Scottish Government's Radioactive Waste Management Policy and the Nuclear Decommissioning Authority's (NDA's) strategy on management of LLW from the UK nuclear industry.

Planning Permission

A planning application was initially lodged with the Highland Council in June 2006. The period for the determination of this application was extended to allow the Scottish Environment Protection Agency (SEPA) sufficient time to assess fully the supporting Environmental Safety Case (ESC). The planning application was re- activated in May 2008, and planning permission was granted by Highland Council in April 2009. The planning permission included 26 conditions on DSRL, covering a wide range of environmental issues such as construction noise/dust, traffic, visual impact and also a condition to develop a community fund aimed at socio-economic development of the area around the Dounreay site.

Phase One Vault Construction

After undertaking the necessary detailed design work, construction of the phase one vaults commenced in November 2011 by principal contractor, Graham Construction. Work was undertaken on both vaults simultaneously, excavating around 243,000m^3 of rock. When excavation was complete, steel reinforcement was placed and concrete poured to construct the floor slabs. This was followed by the construction of the reinforced walls and then the installation of the steel support structure and materials that form the roof. Mechanical and electrical installation then followed, in parallel with the construction of the vault apron, ramps and access roads.

A pumping system and control building was also constructed to remove groundwater from around the vaults to allow the vaults to be kept dry while they are being filled with waste. A layer of excavated material, approximately 3m thick, was placed across the existing ground surface between the vaults and the coast, to ensure the water table lies well below the new ground surface after closure of the vaults, and that any future trace contaminated groundwater flows out to the sea rather than to the soil zone. This layer is referred to in project documents as the "enhanced geosphere". After disposals are completed and the vaults are closed, this layer will be joined to the capping over the vaults so that the ensemble merges visually with the surrounding landscape. The original vegetation and soil mix will be returned as far as is practicable.

Encapsulation Plant Construction

An encapsulation plant has been constructed to fill the LLW containers with grout prior to disposal in the vault, similar to the process used at the national Low-Level Waste Repository facility (LLWR), near Drigg in Cumbria. The plant has the capacity to grout up to four containers per day. The grout fills voids in the container and helps provide chemical conditions in the vault that limit the release of radionuclides in the far future, after the vault has been penetrated by groundwater.

Active Commissioning & Operations of the Encapsulation Plant and LLW Vaults

On April 24 2015, active commissioning began at the Encapsulation Plant and LLW Vaults. Half-height ISO containers packed with low level waste are currently being filled with grout and disposed of in the LLW Vault. Also packaged Demolition Low Level Waste (DLLW) is being processed and disposed of in the Demolition Low Level

Waste Vault. To date over 2500 packages of DLLW and 70 containers LLW have been disposed of.

Completion of construction and the start of operating the Phase One vaults and encapsulation plant are fundamental to the successful and efficient decommissioning of the Dounreay site, upon which many millions of pounds of investment and hundreds of jobs rely.

Introduction

The Dounreay site requires facilities to dispose of the large volumes of low level waste (LLW) that has been and will continue to be generated during the decommissioning and restoration of the site. In May 2014, construction of two new vaults for the disposal of LLW at Dounreay was completed, including the necessary roads, infrastructures and services, followed by an encapsulation plant in September 2014. The vaults are located immediately to the northeast of the Dounreay licensed site, on NDA-owned land.

The facilities are for disposal of the solid LLW generated at Dounreay and the adjacent Vulcan site only. The vaults are being constructed in phases. The first two vaults constitute phase one. In total, DSRL has planning permission for up to six shallow, sub-surface concrete vaults. DSRL has determined it requires at least two further vaults to accommodate low level waste arisings from the decommissioning of Dounreay.

The two vaults constructed in phase one are for two kinds of LLW with different levels of radioactivity. The “Demolition LLW” vault is for waste at the low end of the

radioactivity scale for LLW, and requires less engineered handling and disposal procedures. Demolition LLW is mainly lightly contaminated rubble from demolition of buildings on the Dounreay site. The "LLW vault" is for all of the rest of the LLW, which requires more engineered packaging to be safely handled, and for which different disposal procedures have been developed.

When the vaults are full, they will be closed and any remaining excavated voids filled in. The roofs will be removed and the tops capped over with engineered materials, and the area restored as closely as possible to its original setting using appropriate landscaping.

This paper summarises the construction of the two phase one vaults and the encapsulation plant, as well as giving some background detail on the approach to LLW management at Dounreay, how DSRL came to the decision to construct the facilities at this location, the approvals required, the main safety and environmental issues that have been addressed and the stakeholder management required during a project of this scale.

Phase One Construction

After undertaking the necessary detailed design work, construction of the phase one vaults commenced in November 2011 by principal contractor, Graham Construction. Work was undertaken on both vaults simultaneously, excavating around 243,000m^3 of rock. Blasting was used over a four month period to help minimise the duration of the construction period and reduce construction impacts on local residents.

When excavation was complete, steel reinforcement was placed and concrete poured to construct the floor slabs. This was followed by the construction of the reinforced walls and then the installation of the steel support structure and materials that form the roof. Mechanical and electrical installation then followed, in parallel with the construction of the vault apron, ramps and access roads.

The following photographs illustrate the excavation and construction of the two vaults.

June 2012 – excavation work

August 2012 – installation of floor slab

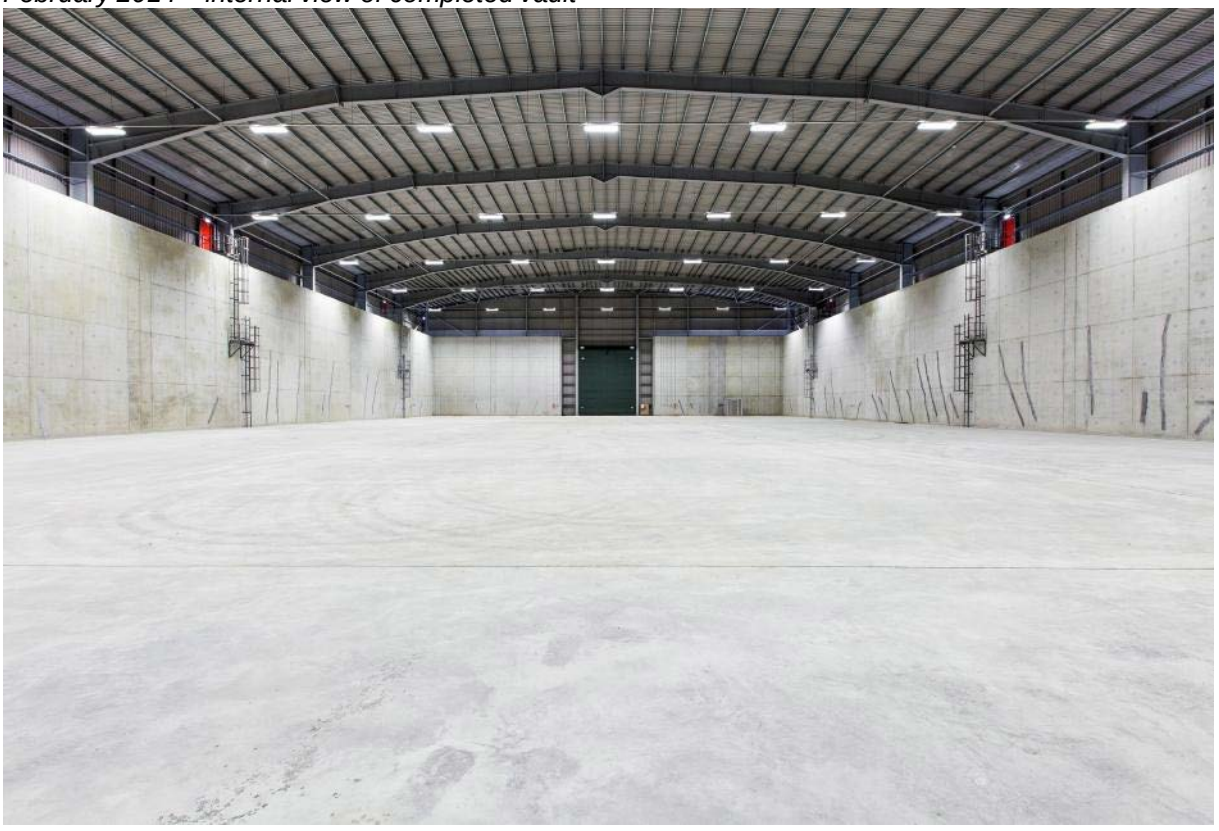
November 2012 – construction of re-inforced walls

October 2012 – aerial view of construction

February 2013 – construction of re-inforced walls complete

May 2013 – roof installation complete

February 2014 – internal view of completed vault



A pumping system and control building was also constructed to remove groundwater from around the vaults to allow the vaults to be kept dry while they are being filled with waste.

A layer of excavated material, approximately 3m thick, was placed across the existing ground surface between the vaults and the coast, to ensure the water table lies well below the new ground surface after closure of the vaults, and that any future trace contaminated groundwater flows out to the sea rather than to the soil zone. This layer is referred to in project documents as the “enhanced geosphere”. After disposals are completed and the vaults are closed, this layer will be joined to the capping over the vaults so that the ensemble merges visually with the surrounding landscape. The original vegetation and soil mix will be returned as far as is practicable.

Encapsulation Plant

An encapsulation plant has been constructed to fill the LLW containers with grout prior to disposal in the vault, similar to the process used at the national Low-Level Waste Repository facility (LLWR), near Drigg in Cumbria. The plant has the capacity to grout up to four containers per day. The grout fills voids in the container and helps provide chemical conditions in the vault that limit the release of radionuclides in the far future, after the vault has been penetrated by groundwater.

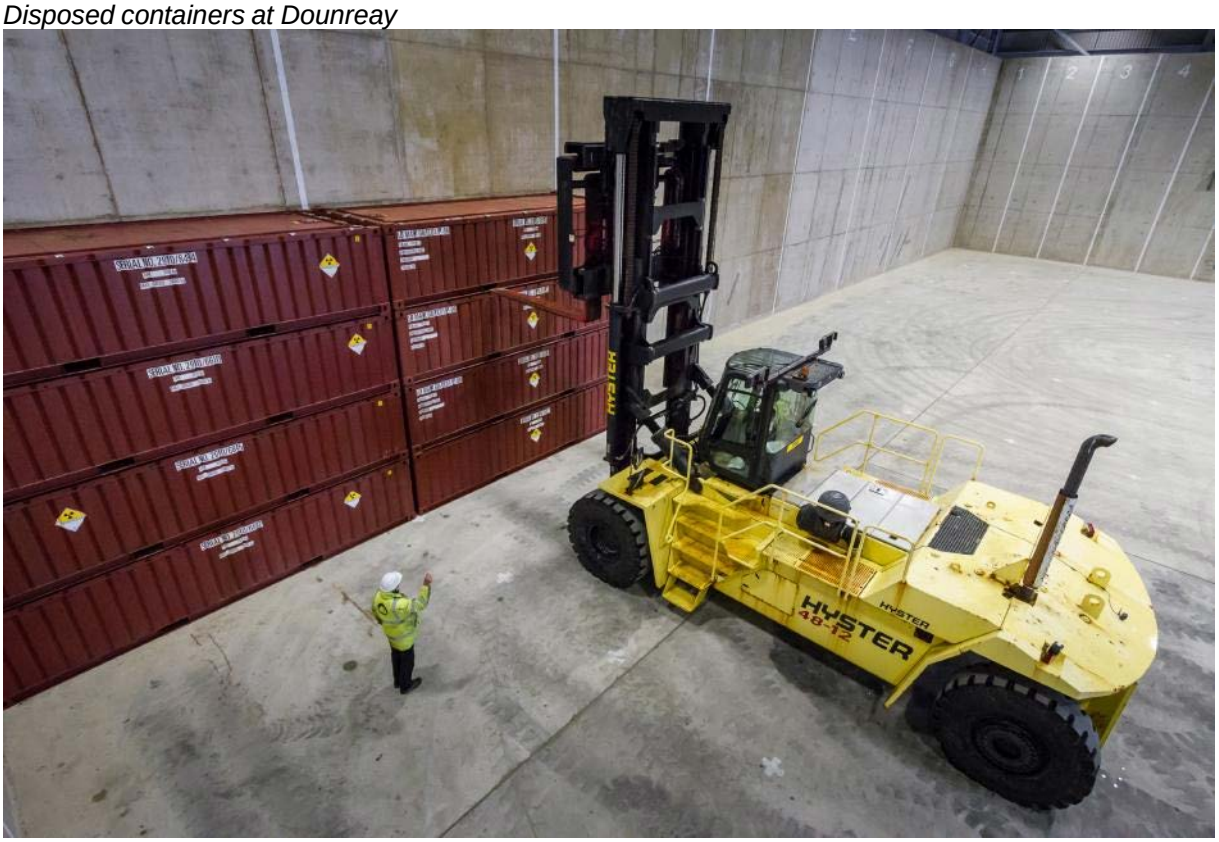
Encapsulation Plant

Construction of the vaults was complete in May 2014, followed by the encapsulation plant in September 2014. Following completion, both facilities underwent inactive and active commissioning; a process that ensures the plant is ready to go operational.

Grouted containers will initially be stacked four-high in the LLW vault. Once the vault is full to this level, gaps between the containers will be backfilled with cementitious material. A reinforced floor will be constructed above the containers and the access

ramp raised to this level. Further grouted containers will then be stacked four-high in the vault. Again, any spaces around the waste containers will be backfilled with cementitious material. The vault will then be covered by a reinforced concrete slab. To date over 70 containers have been grouted and disposed in the LLW vault.

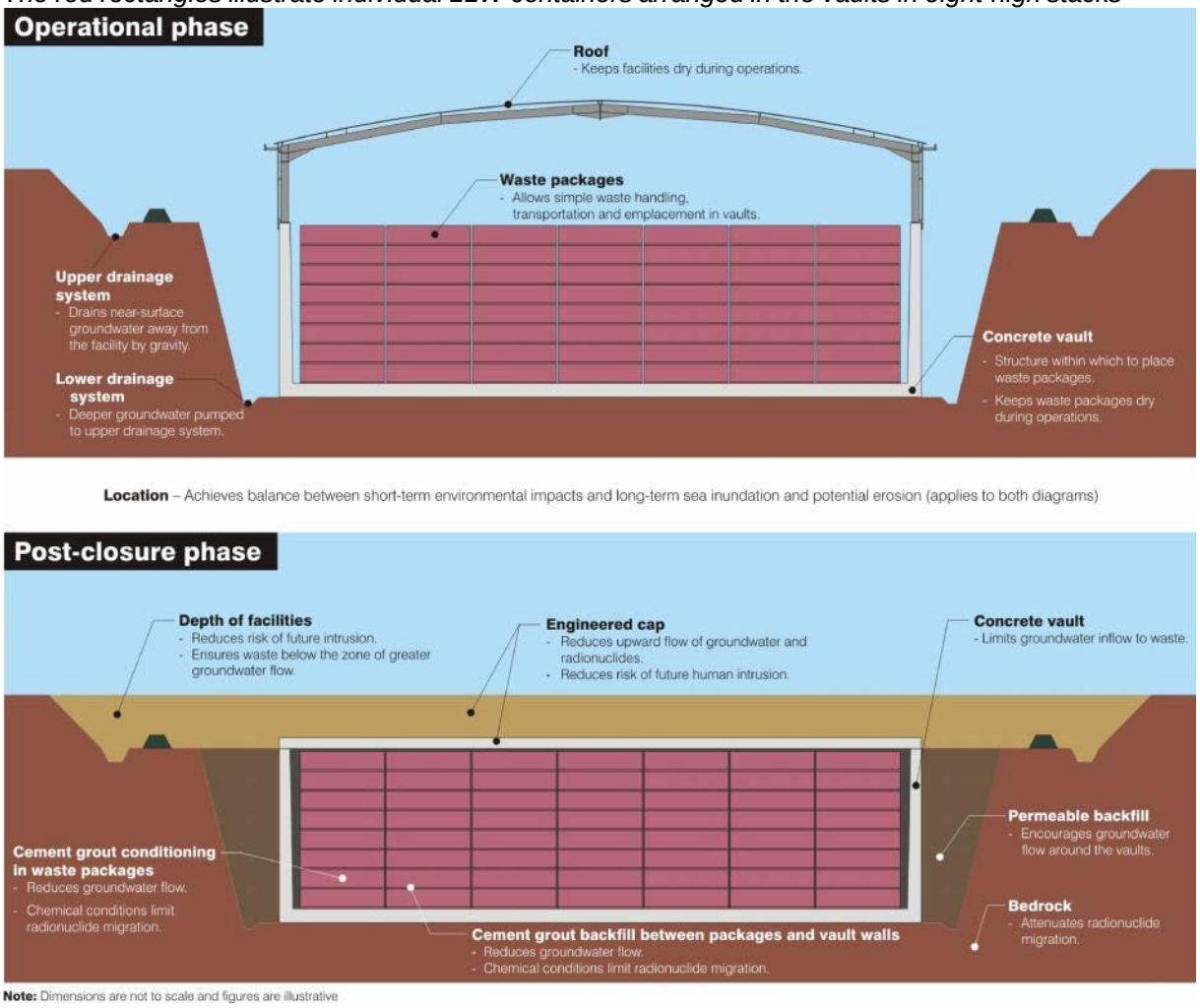
Disposed containers at Dounreay



The Demolition LLW will be disposed of in large nylon bags and emplaced in the concrete vault without the use of grout. This vault will be backfilled with inert granular material (e.g. sand or crushed rock). This, along with waste compaction during the operational phase will help to minimise voids and stabilise the waste. Once full, the vault will be covered with a flexible low-permeability material to allow for any subsequent settlement of the waste. To date over 1200 containers of Demolition LLW has been disposed.

The two vaults and the access roads will be covered by a cap containing an anti-intrusion layer over the vaults and a low-permeability layer to isolate deeper groundwater from the more active near-surface groundwater system.

Illustrations of a LLW disposal vault during operations (top) and after closure and capping (bottom). The red rectangles illustrate individual LLW containers arranged in the vaults in eight-high stacks



LLW at Dounreay

DSRL needs to manage up to 175,000 cubic metres of solid LLW that will be generated from decommissioning of the Dounreay site. Solid LLW includes metals and concrete, glass, soils and other materials, such as polythene sheets, plastic gloves and paper, which have been contaminated with radioactivity. It is at the low end of the radioactivity level range in the radioactive waste spectrum. It contains less than 0.01% of the radioactivity that is present in radioactive waste on the Dounreay site, but comprises about 80% of the solid radioactive waste by volume that is expected to be created during operation and decommissioning of the site.

Photograph showing typical contents of a drum of Dounreay LLW.

An integral part of the decommissioning programme at Dounreay is the requirement to manage the LLW that will be produced. A project was initiated in 1999 to identify and implement the best long-term solution for managing the LLW generated during the restoration of the Dounreay site.

How did DSRL come to the decision to construct these facilities?
In 2004, following consultation with stakeholders and members of the public, Dounreay issued the "Best Practicable Environmental Option (BPEO) Report" on the management of Dounreay LLW. This report assessed potential management options for LLW against a range of criteria, including technical, environmental, cost, health and safety issues.

The study was conducted in line with best practice and involved consultation with a range of people, including the local community and organisations with an interest in radioactive waste management. The recommendations and conclusions from the study provided the basis for the "Dounreay Solid LLW Overall Strategy", which was published in March 2005. A fundamental component of this strategy was the development of new below-ground disposal vaults for LLW at Dounreay. Siting the vaults on land at Dounreay avoids any need to transport the LLW away from Dounreay on public roads. Disposal at Dounreay therefore satisfies the proximity principle of managing the waste at source. Disposal at Dounreay is also consistent with UK Government Policy on LLW management, and the Nuclear Decommissioning Authority's (NDA's) strategy on management of LLW from the UK nuclear industry.

The Location
The identification of the preferred location for the facilities involved the consideration of a wide range of factors, including environmental impacts, safety and technical issues. It also involved consultation with local residents, representatives and other groups. There was general agreement that the waste should be disposed of at Dounreay. However, as there was insufficient suitable space to construct the vaults on the Dounreay licensed site itself, they were sited immediately to the northeast of the existing Dounreay licensed site.

The location strikes a balance between long-term safety considerations and the desire to minimise impacts on nearby residents from the construction and operation of the vaults. In particular:

- The vaults are located a sufficient distance from the sea to ensure there is no significant risk from coastal erosion or flooding of the vaults.
- The layout has been adjusted to avoid a major geological fault in the development area, the exact position of which was determined by site investigation work.
- The vaults have been located to minimise, as far as is practicable, potential noise and visual intrusion for local residents.

Other factors were also considered, such as the occurrence of protected species, (e.g. Scottish Primrose), archaeological sites (e.g., the Cnoc-na-h'Uiseig chambered cairn), and the need to minimise the overall "footprint" of Dounreay.

Planned layout of vaults (if all six vaults are constructed). The encapsulation plant is on the left-hand side of the figure. A temporary storage area for excavated rock is on the right-hand side of the figure. The three phases of paired vaults are illustrated from left to right between the encapsulation plant and the rock store

Approval process

Detailed site investigation, design and assessment studies were undertaken, and DSRL applied for and received planning permission to construct the disposal facilities at Dounreay. A planning application was initially lodged with the Highland Council in June 2006. The period for the determination of this application was extended to allow the Scottish Environment Protection Agency (SEPA) sufficient time to assess fully the supporting Environmental Safety Case (ESC). The planning application was re-activated in May 2008, and planning permission was granted by the Highland Council in April 2009. The planning permission included 26 conditions on DSRL, covering a wide range of environmental issues for which the Highland Council is responsible, such as construction noise/dust, traffic and visual impact. This approval represented a significant step in securing the future decommissioning programme for Dounreay.

Following three successful blasting trials, DSRL applied to the Highland Council for additional permission to excavate via blasting in October 2011. This permission was granted in November 2011 and included an additional seven conditions on DSRL relating specifically to blasting operations and the protection of local residents.

DSRL also applied to SEPA for the necessary authorisation to dispose of radioactive wastes in the vaults. An authorisation from SEPA is required under the Radioactive Substance Act 1993. An ESC was developed to demonstrate that the waste will be disposed of in a manner 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. The application for the authorisation for the disposal of waste was initially submitted to SEPA in April 2008 and, following dialogue with SEPA, was updated in October 2010 with a revised ESC. An authorisation with conditions was issued by SEPA in January 2013. In August 2014, DSRL submitted operational documents to SEPA for review. SEPA's written agreement to allow disposal operations was obtained in March 2015. SEPA will

continue to regulate the vaults over their operational lifetime, until such time after their closure when the vaults can be considered safe to be released from further regulatory control.

Radiological safety

The vaults have been designed to contain the radioactive content of the waste within the vaults for as long as is practicable. The radioactivity is contained in two main ways. First, the packaging, backfill, and concrete structure of the LLW vaults restrict groundwater flow through the LLW, reducing the amount of radioactivity that can be leached out. Second, the cement-based grout alters the chemical conditions within the groundwater, effectively reducing solubility of radionuclides and binding radionuclides to the grout, again reducing the amount of radioactivity that can be released.

The radioactivity levels in the Demolition LLW vaults are so low that they pose very low risks to people and the environment. Therefore, the waste packaging is less robust and no grout is used in either packaging or backfilling the Demolition LLW vaults.

Following capping and closure of the vaults a period of institutional control and monitoring will follow, to provide reassurance that the vaults are functioning as intended. The radioactivity within the waste will reduce naturally over this time owing to the process of radioactive decay. After 300 years, over 95% of the initial activity in the disposed waste will have decayed. Beyond this period, there is no requirement for any institutional control, as there will be little or no hazard associated with the waste, and the cap will continue to deter any accidental human intrusion into the vaults.

There are many natural sources of radioactivity within the environment that people are exposed to every day, e.g. radon gas, rocks, soil and cosmic radiation (from the sun). These naturally occurring sources are termed background radioactivity. Assessments have calculated that concentrations of radioactivity in the environment coming from the waste disposed of in the vaults would never exceed levels similar to naturally occurring background radioactivity. Therefore, they never reach levels that might be of concern from the perspective of public health and safety.

The ESC demonstrates that there will be no significant risk to people as a result of the radioactivity in the disposed waste. In addition, the calculated concentrations of radionuclides that might enter the environment in the future are so low that there will be no significant impacts on either fauna or flora.

Other Environmental Impacts

The Environmental Impact Assessment conducted in support of the planning application considered other possible environmental impacts of the vaults during their construction, operation and closure, and beyond. The site selection process minimised many environmental impacts, but some impacts were inevitable, such as noise, dust and vehicle movement during construction. The most significant of these occurred during the vault construction stage, with no significant impacts expected during operation, and some impacts expected during vault closure and restoration of the area.

Noise and visual impacts were minimised by locating the vaults over the brow of a hill and as far from neighbouring properties as is practicable. Noise during construction

was minimised through implementation of best working practices such as using quiet plant, shrouding of equipment and switching machinery off when not in use. Following dialogue with stakeholders and additional permission from Highland Council, blasting was used for excavation of the vaults in order to minimise the duration of the construction period and reduce construction impacts.

Impacts to air quality were anticipated mainly through the generation and spread of dust, particularly during excavation and construction. This was minimised through implementation of best working practices, such as using construction equipment designed to minimise dust generation, ensuring vehicles were clean before leaving site, removal of dust-generating materials as soon as practicable, and cleaning and damping down of roads. The impact was also minimised by increasing the distance of the vaults from the nearest local neighbours as far as was practicable.

Transport impacts were minimised through design and location. Keeping the excavated material at an on-site location had a huge effect in minimising vehicle movements on public roads. Further reduction was achieved through a Traffic Management Plan. This included measures such as staggering construction site working to avoid Dounreay peak traffic periods, using on-site materials where possible, and agreeing haulage routes to minimise disruption.

Other environmental impacts were also assessed, and measures were established to minimise those impacts. For example, the Scheduled Ancient Monument, Cnoc-na-h'Uiseig, was fenced off to avoid disturbance. Vault locations underwent archaeological survey and monitoring to identify, record and, where appropriate, carefully excavate archaeological remains of cultural heritage value prior to the start of the main vault excavation works.

Disturbance to birds was minimised though the timing of the commencement of construction and restoration of habitat when the vaults are closed. Impacts on the sea from construction was minimised through the implementation of a specially designed drainage system.

Stakeholder Dialogue and Community Benefits

Many consultation events have been undertaken during this project and dialogue with stakeholders has had a significant input to decisions on the overall LLW management strategy at Dounreay, and on implementing the preferred option of disposal in below-surface vaults adjacent to the Dounreay licensed site. In addition, one of the planning conditions concerns the creation of a liaison group with local residents to ensure dialogue continued on a regular basis throughout construction. DSRL established the Buldoo Liaison Group meeting for the closest residents and the Local Community Liaison Group meeting for wider local residents. In addition, dialogue has continued with statutory and non-statutory stakeholders throughout the construction of phase one. Stakeholder engagement was deemed to be a key part in obtaining the necessary permissions required and also to ensure construction of the facilities was achieved to programme with as little disruption to local residents as possible.

The Highland Council also imposed a planning condition aimed at socio-economic development of the area around the Dounreay site. The NDA committed to pay £4M to the Caithness & North Sutherland Fund - £1M at start of construction and £300,000 per year for the first 10 years of operations. The fund was launched in the autumn of 2011 to distribute funding to projects that can help regenerate the area's economy, in accordance with the NDA's socio-economic policy.

Development Phases

The disposal vaults are being developed in up to four phases, with vaults only being constructed when it is deemed they are required:

- The phase 1 vaults as outlined in this paper have started to accept waste since April 2015.
- The phase 2 will be confirmed as the site decommissioning progresses and waste volumes are updated. The timescale for construction has still to be determined.
- The phase 3 vaults may be needed to cater to future LLW arising.
- The closure phase will involve sealing the vaults, backfilling the excavation around the vaults, emplacing engineered caps over the vaults, and merging the caps with the enhanced geosphere layer. The area will then be restored to blend in as far as is practical with the surrounding environment.

Conclusion

In order to enable decommissioning of the Dounreay site, it is necessary to manage the significant volume of solid LLW and Demolition LLW that will be generated. The best option for managing this waste is with the construction of these new LLW disposal facilities at Dounreay.

Completion of construction of the phase one vaults and encapsulation plant is fundamental to the successful and efficient decommissioning of the Dounreay site, upon which many millions of pounds of investment and hundreds of jobs rely. The package of community support measures put in place recognises the strategically important nature of the facilities.