In Situ Disposal to Optimize Decommissioning Waste Management - 17455

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ABSTRACT

Cavendish Fluor Partnership (CFP) is teaming with the UK government's Nuclear Decommissioning Authority (NDA) to explore opportunities for onsite disposal of structures and wastes from decommissioning of twelve Magnox nuclear sites. CFP is piloting implementation of draft guidance issued by the Environmental Agency (EA), Scottish Environmental Protection Agency (SEPA) and Natural Resources Wales (NRW) designed to optimise management of wastes generated in closing nuclear sites positioned across Scotland, Wales and England. Where it can be demonstrated to be the best overall solution for people and the environment, on-site / in situ disposal as an option for optimising waste management could save millions of pounds sterling in the overall costs for site closure as opposed to previous plans that required retrieval, packaging, transportation and offsite disposal of all radioactive wastes generated during site decommissioning.

The UK government's Department for Business, Energy and Industrial Strategy (BEIS), NDA, and UK regulators are consulting with stakeholders on a proposal to amend legislation and enable better, more proportionate regulation of nuclear sites in the final stages of decommissioning and clean-up. Practical application of existing UK legislation typically means removing most, if not all, radioactive waste and residual contamination from the nuclear licensed site for disposal or management elsewhere, irrespective of any wider health and safety, social, environmental or economic considerations. Proposed changes to legislation would give greater weight to the environment agencies' guidance and provide for a more sustainable approach where optimization could include on-site/in situ disposal solutions and early opportunities to reuse land with appropriate regulatory oversight.

Recent characterization activities at two reactor sites have identified areas of subgrade low level contamination in structures and soil around used fuel ponds. CFP, a partnership of UK-based Cavendish Nuclear Limited and US-based Fluor Corporation, has initiated preliminary site modelling that indicates much of this material, including significant volumes of subgrade structures would be conducive for in situ disposal under the new proposed guidance. Based on Fluor experience with similar decommissioning projects at US Department of Energy sites, CFP will look to leverage in situ disposal to optimise decommissioning waste management and consequently optimise overall facility decommissioning strategies.

INTRODUCTION

Cavendish Fluor Partnership is the decommissioning contractor for the UK Nuclear Decommissioning Authority's twelve Magnox reactor sites. The sites consist of ten former Magnox reactor power generating sites and two former research sites. The current decommissioning strategy and lifetime plans for the ten Magnox reactor sites assumes all collateral buildings are decommissioned and the reactor buildings prepared for a nominal 40-60 years of quiescent "safestore" period referred to as Care and Maintenance (C&M) before demolition at Final Site Clearance. The two research reactor sites are to be taken directly to final site clearance, including decommissioning and removal of five research reactors.

Fig. 1. Location of all 12 Magnox sites

The current lifetime plans for all twelve sites assume removal of all residual radioactive contamination above Out of Scope (free release) levels from the sites by the end of Final Site Clearance (FSC). Free release levels are required in order to be released from the nuclear site license and revocation/surrender of environmental permits/authorisations. Thus, the current strategy and life-time plans for these sites do not allow for any on-site disposal of radioactive waste.

DISCUSSION

Background

Through a recently published Environmental Agency consultation document known as the draft Guidance on Requirements for Release of Nuclear Sites from Radioactive Substances Regulation (GRR) [1], the environment agencies are establishing requirements for operators to optimise decommissioning and waste management strategies for delivering nuclear decommissioning sites to final end states. The draft guidance introduces the opportunity for in situ and on-site disposal as one element of an optimised, integrated waste and decommissioning strategy. Regulators are essentially requiring operators to balance the impacts of retrieving, packaging and shipping all wastes to authorised off-site disposal facilities with the potential impacts of leaving some wastes for on-site disposal.

The new regulatory guidance will require operators to demonstrate optimisation of decommissioning waste management through preparation of an optimised Waste Management Plan (WMP) and supporting Site Wide Environmental Safety Case (SWESC) that assesses the impacts of radioactive waste and residual radioactive contamination planned to be left as part of the final site end state. The SWESC would necessarily have to consider the site's next planned use and would likely incur a period of institutional control before release from regulatory oversight.

Two "lead and learn" Magnox sites (Trawsfynydd and Winfrith) have been identified to trial the new guidance and to assess the effects of the legislative changes proposed by government. As part of this trial, CFP is developing optimised solutions and preparing associated documentation with close interaction with the NDA and regulatory agencies. Lessons learned from the trial sites will be incorporated into the guidance before final issuance.

Optimised end states which may include on-site and in situ disposal have the potential to provide significant benefits for people and the environmental with commensurate cost savings over the lifecycle of a number of Magnox sites. In situ disposal is the in-place disposal of radioactively contaminated substructures. On-site disposal would introduce emplacement of low level radioactive wastes into voids within subgrade structures which also may be contaminated.

Case for Change

The biggest driver for revisiting the baseline strategies for decommissioning Magnox sites is issuance of the environmental agencies' guidance requiring optimisation of waste and decommissioning strategies. The guidance document specifically requires optimisation of key wastes generated during decommissioning where these wastes also include contaminated substructures that could be left in situ.

The base case for ultimately taking sites to Final Site Clearance assumes that facility substructures could be left in place below one meter from the ground surface. This assumption presumes contamination above free release criteria would be removed prior to entry to FSC. Recent characterisation work at both the Trawsfynydd and Winfrith sites has identified more extensive subgrade contamination than originally known (such as from fuel storage pond leakage into and beneath substructures). While the contamination levels are not high, the spread of the contamination is extensive and would have necessitated 1,000s of cubic meters of waste removal to achieve release criteria for nuclear licensed sites.

A recent study by Magnox Ltd has indicated that if fully implemented, on-site and in situ disposition at the 12 Magnox sites could avert the off-site disposal of tens of thousands of cubic meters of low activity LLW demolition debris, and consequently thousands of off-site waste shipments. Cost savings could exceed £100M (mainly from averted off-site LLW disposal costs). Subject to suitable site conditions and a satisfactory SWESC, these opportunities might also extend to emplacement and disposal of low activity wastes within major non-contaminated voids at some sites such as turbine hall voids. Under current planning assumptions, most of the savings from on-site and in situ disposal is likely to be realised at FSC, primarily because the vast majority of LLW concrete will arise from demolition of reactor bio-shields.

In view of the environmental agencies' guidance on in situ disposal and optimisation of waste and decommissioning strategies, some preliminary modelling was conducted on the potential for leaving some contaminated substructures in situ. This preliminary modelling has demonstrated the contamination could be left in situ while achieving the protection objectives for the public and environment. Work is ongoing to demonstrate that, as well as being safe, this represents the best overall solution for people and the environment.

The baseline strategies for taking most sites to Final Site Clearance necessitate management of numerous voids following demolition of reactor buildings and support structures. The largest voids are associated with fuel storage ponds, turbine halls, waste vaults and substructures beneath reactor buildings. The

baseline plans largely call for filling voids with clean infill, necessitating import of substantial volumes of clean infill materials. A Magnox assessment of void volumes and projected demolition debris generated in taking sites to FSC demonstrates that, for most sites, nearly all demolition wastes could be accounted for in existing voids.

Table I provides an overview of the potential scale of savings in terms of averted off-site disposals of reactor bio-shield concrete LLW and consequent averted expenditure (at present money values). Averted off-site disposal volumes and expenditures associated with other contaminated structures such as ponds and vaults, etc. and contaminated ground would generate potential savings in addition to those reflected in Table I. It must be borne in mind that this is all subject to optimisation and compliance with the requirements of the environmental agencies' guidance.

TABLE I – Potential Benefits of In Situ Disposal

Potential savings from Onsite Disposal (OSD) of bio-shield concrete across 10 sites	Averted volumes for off-site disposal (m^3)	Averted costs (£M)
OSD limited to footprints of existing radioactive features on site	63,000	£250M
OSD extended to use existing on-site turbine hall voids at Sizewell A, Oldbury & Wylfa	150,000	£600M
OSD extended to fullest credible potential including on adjacent site or by land-raise (landform re-profiling)	205,000	£820M

This study also included a preliminary assessment of the viability of sites for safely accommodating on site and in situ disposals. These results highlighted the variability of site suitability for in situ disposal with key discriminators being availability of void volumes and risk of coastal erosion. This study of void volumes and suitability for in situ disposal is summarised in Appendix 1.

Ultimately, the decision to consider the option for in situ disposal will be an expected requirement from the draft regulator guidance requiring sites to optimise waste and decommissioning strategies. That optimisation requires that sites consider all implications with waste management and disposition including:

- Ensuring worker safety;
- Minimising waste generation and providing for effective and safe management of wastes that are created;
- Minimising environmental effects including the re-use and recycling of materials;
- Using resources effectively, efficiently and economically;
- Using best practice;
- Public acceptance;
- Proportionate site decommissioning and clean-up; and
- Ability to substantiate the approach through a Site Wide Environmental Safety Case, taking into account radioactive waste and/or contamination still remaining on or adjacent to a site.

In addition to the general considerations identified above, the operator will be required to consider the following in assessing options:

- The extent to which is it is proportionate to remediate radioactively contaminated land and groundwater on or adjacent to a site;
- The availability of suitable disposal facilities for radioactive waste retrieved or created;
- The effort and cost of retrieving or creating the waste and putting it into a form suitable for transport and disposal;
- The effort and cost of transport and disposal themselves; and
- Radiation exposure and other sources of risk associated with all the operations involved

As stated above, a preliminary assessment indicates that there is waste and residual contamination at some sites that may be suitable for on-site and in situ disposal as substantiated through a Site Wide Environmental Safety Case (SWESC). Requirements which must be demonstrated through site-wide all-pathways modelling include:

- Meeting specified dose criteria during the periods of environmental oversight. Doses should not exceed:
    - 0.3 mSv per year from any source from which radioactive discharges are made; and
    - 0.5 mSv per year from the discharges from any single site.

- Meeting a risk guidance level of 10^{-6} per year (that is, risk of death of 1 in a million per year due to exposure to ionising radiation) from the remaining radiological hazards to a person representative of those at greatest risk after release from radioactive substances regulation.
- Meeting a human intrusion dose guidance level after the site has reached the point at which it could be released without institutional control. The assessed effective dose to any person during and after the assumed intrusion should not exceed a dose guidance level in the range of around 3 to 20 mSv per year. Values towards the lower end of this range are applicable to assessed exposures continuing over a period of years (prolonged exposures), while values towards the upper end of the range are applicable to assessed exposures that are only short term (transitory exposures).

Ultimately, the case for change arises primarily from the fact that the current Site End States for the Magnox reactor sites (as stated in the Magnox Ltd strategy and lifetime plans) are constrained and thus not demonstrably optimised. These constraints need to be both understood and tested from the perspectives of NDA Strategy and Value Framework, UK-wide LLW policy and strategy and Radioactive Substances Regulation (RSR) requirements.

A Magnox Ltd study in support of this paper [2] has explored the potential for on-site and in situ disposal within the footprints of existing radioactive features of each site. This study strongly suggests that the current strategy for the Magnox reactor sites is unlikely to be the optimised waste and decommissioning solution for some sites, either in the near term (prior to C&M entry) or in the long term (after FSC). A summary of the study's preliminary findings across the 10 Magnox reactor sites is presented in Appendix 1. The study shows that:

- The overall volumetric potential for on-site and in situ disposal within the footprints of existing radioactive features is greatest at the two sites (Bradwell and Trawsfynydd) where the reactor bio-shields are about 50% below ground level.
- significant environmental and cost benefits over applicable sites' life-cycles, including averting thousands of large vehicle waste movements for off-site transport of LLW for disposal and of the order of £360M (mainly averted off-site LLW disposal costs).
- Indicative savings across the 10 sites that could potentially be realised by implementing on-site and in situ disposal within the footprints of existing radioactive features were calculated as being of the order of £250M for bio-shields, £70M for ponds/vaults and £40M for radioactively contaminated land, with the majority of savings realised at FSC.

In summary, the current decommissioning strategy for the sites warrants revisiting within the context of emerging expectations for demonstration of optimised waste management for sites entering the final stages of decommissioning.

Collaborative Approach

Early progress in pursuing the potential savings from on-site and in situ disposal can be attributed to the exceptional collaboration between Magnox, Regulators and the NDA. Prior to issuance of the environment agencies' draft guidance, a Site End States Senior Strategy Group (SES-SSG) was established with representation from Magnox, Dounreay Site Restoration Limited, England's Environmental Agency, the Scottish Environmental Protection Agency, Natural Resources Wales, and the UK Government's Office of Nuclear Regulations and Department of Business, Energy and Industrial Strategy. This strategy group was chartered with the objective of providing strategic guidance to three lead and learn sites piloting use of the draft guidance. In turn, these three "Lead and Learn" sites at Winfrith (England), Trawsfynydd (Wales) and Dounreay (Scotland) have established Tactical Teams with similar representation to oversee site-specific implementation of the draft guidance.

As implementation has progressed, members of the three site Tactical Teams have met to ensure consistency of approach and to highlight strategic issues warranting further guidance and/or resolution from the SES-SSG. Those issues elevated to the SES-SSG are tasked to member organisation for resolution and feedback to the site Tactical Teams.

The three sites are progressing with development of draft Waste Management Plans and Site Wide Environmental Safety Cases which will ultimately serve as the key underpinning documents required for environmental agency authorisation of in situ disposal.

The common objective of all organisations participating in this effort is optimised decommissioning of nuclear facilities. This collaborative approach is facilitating expedited development of new regulatory guidance in a manner that should ensure impacted sites can readily understand, implement and realise intended benefits.

CONCLUSIONS

Through strong co-operation between the UK NDA, Regulators and decommissioning sites, there exists the real opportunity to substantially optimize delivery of site decommissioning programs through introduction of on site and in situ disposal for some low activity waste forms. This optimization offers the opportunity to significantly reduce waste excavations, retrievals, packaging, shipping and off-site disposal while still demonstrating safety for the environment and public. That strong co-operation will be critical as proposals to amend legislation and are finalized and implementation of guidance is trialled at demonstration sites in the coming years.

REFERENCES

[1] Magnox Ltd, “Preliminary assessment of the potential for in-situ/on-site disposal of radioactively contaminated structures and land at Magnox reactor sites,” M/WF/GEN/REP/0009/15 Issue 222, August 2016.

[2] Environment Agencies, “Guidance on requirements for release of nuclear sites from Radioactive Substances Regulation” (Consultation Document), February 2016.

APPENDIX 1: SUMMARY OF ASSESSMENTS FOR POTENTIAL AT EACH SITE

		Berkeley	Bradwell	Chapelcross	Dungeness A	Hinkley Point A	Hunterston A	Oldbury	Sizewell A	Trawsfynydd	Wylfa
Assessment outcomes	Assessment of life-cycle potential for OSD[23] to affect site end state	Moderate potential	Large potential (with caveats)	Limited potential	Limited potential	Moderate potential	Moderate potential	Moderate potential	Limited potential	Large potential	Limited potential
	Assessment of near-term potential for OSD[23] to affect C&M preparations for radioactive features of site	Moderate potential	Limited potential [too near C&M]	Limited potential	Limited potential	Moderate potential	Large potential	Limited potential [ponds within reactor block]	Limited potential	Large potential [in principle]	Limited potential
Key inputs to assessments	Position of bio-shields with respect to ground level	Pre-dominantly (>80%) above-ground	Mainly (about 50%) below ground	Pre-dominantly above-ground (only base slab below ground)	Pre-dominantly (>80%) above-ground	Pre-dominantly (>80%) above-ground	Entirely above ground level	Mainly (>50%) above-ground (but not pre-dominantly)	Pre-dominantly above-ground (only base slab below ground)	Mainly (about 50%) below ground	Pre-dominantly (>80%) above-ground
	Scale of below-ground radioactive features other than bio-shields	Medium [including vaults but not ponds[24]]	Substantial [including ponds and vaults]	Small	Substantial [including ponds]	Medium [including vaults but not ponds]	Substantial [including ponds, land and CW discharge shaft/tunnel]	Substantial [including ponds]	Small	Substantial [including ponds and vaults]	Small
	Key adverse site-wide factors	None	None	• Sensitive aquifer	• Coastal erosion • Sensitive aquifer • Local policy against OSD	None	None	None	• Coastal erosion • Sensitive aquifer	None	None
Status of turbine hall void		Already fully in-filled	Limited infill	Minimal void present	Already largely in-filled	Already largely in-filled (~10,000 m^3 un-filled)	Already fully in-filled (ILW Store on footprint)	No infilling to date (~52,000m^3)	No infilling to date	Relatively small void already in-filled	No infilling to date (~86,000m^3)