SOLID LOW LEVEL RADIOACTIVE WASTE MANAGEMENT WITHIN BRITISH NUCLEAR FUELS plc

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Abstract

BNFL owns and operates the principal UK solid low level waste (LLW) disposal site which is located at Drigg in West Cumbria. Disposal of LLW into shallow open cut trenches commenced in 1959. In 1987, however, BNFL announced a major program of improvements to operations at the site. This paper reviews progress to date, outlines possible future developments and describes the underlying development program.

INTRODUCTION

The main activities of British Nuclear Fuels plc (BNFL) are the provision of nuclear fuel cycle services to the UK electricity generating industry and to overseas customers. The Company's Head Office is located at Risley in Cheshire; with production facilities at Springfields (Lancashire), Capenhurst (Cheshire), Sellafield (Cumbria) and Chapelcross (Dumfriesshire). The main elements of the services provided are:

- uranium enrichment (Capenhurst);
- fuel manufacture (Springfields);
- reactor operation (Sellafield and Chapelcross);
- spent fuel reprocessing (Sellafield).

In addition to the above facilities, BNFL owns and operates a solid low level waste (LLW) disposal site which is situated at Drigg some 4 miles south east of the Sellafield site. This site handles LLW arisings from both the Company's activities and other UK producers of solid LLW.

During recent years, BNFL has embarked upon a major program of improvements at Drigg. This paper reviews progress to date, outlines possible future developments and describes the underlying development program.

SOLID LOW LEVEL RADIOACTIVE WASTE ARISINGS

The UK Radioactive Waste Management Advisory Committee (RWMAC) classifies low level waste (LLW) as being "that material containing radioactive substances, other than those very low level wastes which are acceptable for dustbin disposal (less than 400kBq in any $0.1m^3$ or $3\mu Ci$/cu ft), but not exceeding 4GBq/t (120mCi/ton) alpha or 12GBq/t (360mCi/ton) beta gamma".

The major source of solid low level waste is from fuel reprocessing operations at Sellafield. Additional sources include other BNFL production establishments, nuclear power stations, United Kingdom Atomic Energy Authority sites, Ministry of Defence facilities, hospitals, universities, radio-chemical sites and various industrial organisations.

The composition of solid low level waste is highly heterogeneous and includes materials such as cellulosics, plastics, metals, soil and rubble. Typically, about 70% by volume of the waste as it arises is soft, low density material. Raw waste is generally assumed to have a packing efficiency of 10% and an average bulk density of about 0.3 t/m^3 (18.75 lb/cu ft).

In recent years, the average rate of arisings from Sellafield (prior to any pretreatment or containerisation) has been about 25 $000m^3$ (880 000 cu ft) per year, although this is expected to rise to about 40 $000m^3$ (1 400 000 cu ft) per year as new plants come on line. Arisings from other sources have in the past combined to generate about 13 $000m^3$ (460 000 cu ft) per year but recent estimates suggest that future arisings from these other sources will fall to some 6 $000m^3$ (200 000 cu ft) per year (prior to any pre-treatment or containerisation) primarily as a result of more careful segregation of very low level waste at source.

THE DRIGG SITE AND PAST DISPOSAL PRACTICES

Consent to dispose of solid low level waste at Drigg was granted in 1957 and disposal operations started in 1959. The site has a total area of about 270 acres and runs parallel with the coast, about half a mile from the sea. The geology at Drigg consists of a complex heterogeneous sequence of glacial sediments overlying an irregular surface of red sandstone bedrock. The glacial deposits range from compacted clays through silts to coarse sand and gravels.

Only the northern 88 acres of the site are currently consented for disposal of low level waste. Within this area there is an essentially continuous clay layer at about 5-8 metres depth. Past disposal operations have involved the use of trenches cut so that the clay layer forms a graded, low permeability base. Infiltrating rain and groundwater is thus directed to the southern end of the trenches, where it is collected by a series of drains and discharged to the Irish Sea via the Drigg Stream and the River Irt. Waste was tumble tipped into the trenches, working from the northern end. As the level of the waste approached the prescribed depth below existing ground level, it was covered with earth. A layer of small boulders and a geotextile sheet were incorporated into this layer to form a stable surface, from which further disposal operations could continue. This method of disposal is now being phased out but continues on a temporary basis for Sellafield waste.

CONTROL OF DISPOSALS

Authorisation for disposal of LLW at Drigg is granted by the Department of Environment and the Ministry of Agriculture, Fisheries and Food under the terms of the Radioactive Substances Act, 1960. This authoriaztion is reviewed on approximately a three yearly cycle. The main conditions of the current authoriaztion are:

- that the activity in any one consignment should not exceed 4GBq/t (120mCi/ton) alpha emitting radionuclides or 12GBq/t (360mCi/ton) other radionuclides;
- the use of best practicable means to compact waste before disposal;
- the use of best practicable means to limit the migration of any radionuclides from the waste disposed;
- specific concentration limits on specified groups of nuclides in the leachate leaving the site;
- annual limits for certain individual and groups of radionuclides allowed for disposal.

BNFL also imposes certain conditions for acceptance of waste at Drigg aimed at meeting both technical and radiological safety criteria as well as legal requirements.

CURRENT UPGRADE OF DRIGG OPERATIONS

The Drigg Strategy has evolved over a number of years, encompassing the results and recommendations of a series of studies. Despite risk assessments continuing to demonstrate the radiological acceptability of disposal of LLW in trenches, BNFL announced in September 1987 that a major program of improvements was to be implemented at Drigg. This program included:

- capping and provision of groundwater cut-off walls to limit rainwater infiltration and lateral migration of groundwater;
- the refurbishment of the leachate drainage system;
- containerization of waste with compaction where appropriate;
- provision of concrete vaults for future disposals.

The main aims of the program were to conserve capacity within that area of the site consented for disposal, improve leachate management and provide a positive response to growing public, political and regulatory criticism of the visual impact of tumble tipping. The program of improvements is now largely complete as described below.

A temporary cap comprised of a 1:25 graded earth mound incorporating an impermeable low density polyethylene membrane has been constructed over the completed trenches. This will subsequently be replaced by a permanent cap incorporating a thick band of clay once settlement is judged to be complete. A groundwater cut off wall keyed into the clay layer underlying the trenches has also been installed around the north east corner of the site, in order to control a known pathway for leachate migration and to control groundwater outflows and inflows.

The trench drainage system has been refurbished and flow proportional sampling equipment has been installed. Refurbishment of an existing marine outfall (remaining from the site's previous use as a Royal Ordnance Factory) is currently in progress. This will permit controlled discharge of leachate direct to sea at high water, thus eliminating discharge of leachate to surface environments.

Waste containerization is being introduced on a phased basis. Waste from non-Sellafield consignors is now routinely despatched to Drigg in either full or half height ISO freight containers. These are emplaced in a new concrete vault (Vault 8) which was completed in January 1989. This has a nominal capacity of about 180 000m^3 (6.4 million cu ft). Sellafield waste continues to be tumble tipped on a temporary basis, pending provision of a combined compaction and packaging plant at Sellafield.

Plans are being developed for the introduction of compaction of both Sellafield and non-Sellafield waste. It is currently intended that Sellafield waste will be loaded into nominal 1m^3 boxes, possibly with pre-compaction, for subsequent high force compaction (HFC). The use of 1m^3 (35 cu ft) boxes rather than standard 200 litre (55 US Gal) drums will permit a much greater quantity of waste to be directed to the compactor, thus achieving a higher overall volume reduction. Detailed plant design is now in hand and it is currently envisaged that full operation will commence around mid-1993. Suitable non-Sellafield waste is already routinely loaded into 200 litre drums. These will either be high force compacted at the consignor's site, or processed through the Sellafield compaction plant, depending upon the preference of the individual consignors.

FUTURE DEVELOPMENTS

Figure 1 shows an artists impression of the main features of the systems now being brought into use at Drigg. The main features to note are:

- the exclusive use of ISO freight (land/sea) containers;
- the continued use of the natural clay layer (augmented where necessary with engineered clay) which in turn limits the depth of the vault and hence the maximum stack height;

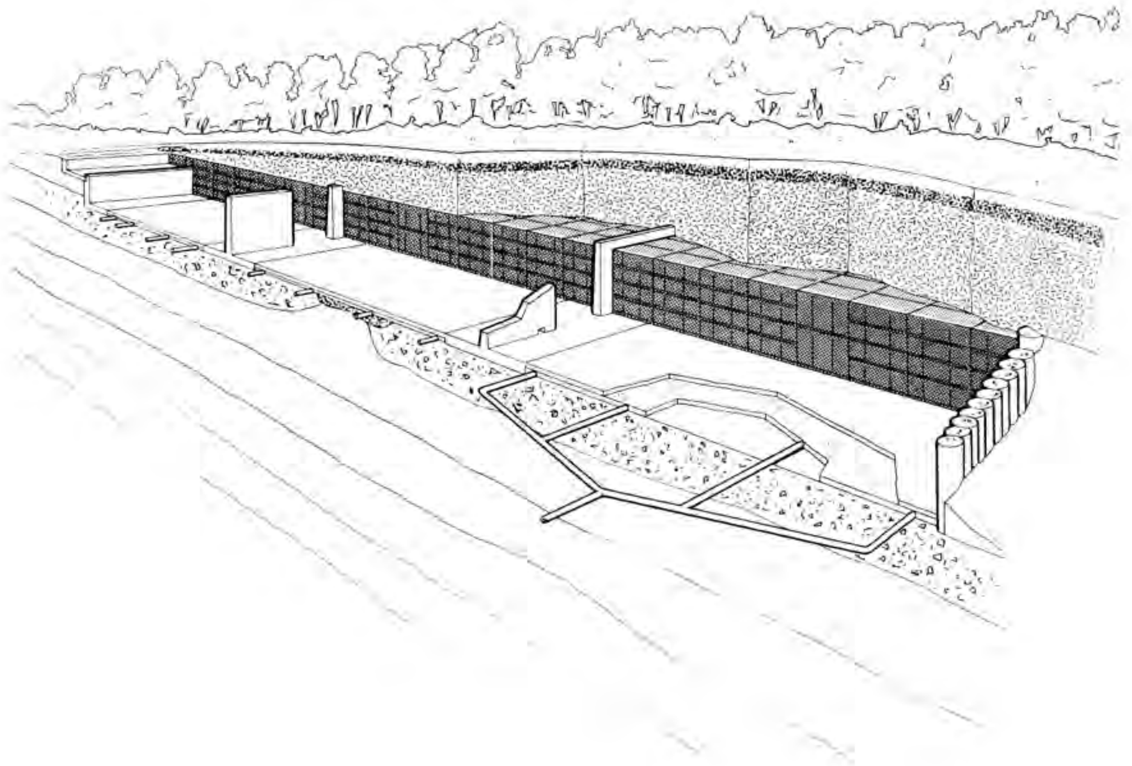

Fig. 1. Vault Design Current Concepts.

- the provision of horizontal drains which are discharged to sea via the marine pipeline;
- the adoption of a domed cap.

Due to the relatively short timescale over which the program of improvements has been implemented (an overriding criteria being to ensure that operational availability of the site was not disrupted), it was recognised that the measures introduced to date may only be an interim solution and that there may still be scope for further improvements. Indeed, detailed studies and assessments have continued throughout the period of implementation of the current program of improvements. Where feasible, relevant conclusions have been taken on board in the current phase, and a number of other measures have been identified for future phases.

The most recent development relates to the long term stability of the site. Assessments indicate that, despite the introduction of compaction, voidage in the vault could still be significant. Further, the degradation of the ISO freight containers (particularly under the anaerobic conditions that would prevail after emplacement of the cap) could span some hundreds of years. Joint consideration of these two facts led to the conclusion that there may be a high risk of sudden, major settlement of the site with consequential extensive cap disruption. It is currently proposed, therefore that all readily accessible voidage should be in-fill grouted and consideration is being given to the use, where possible, of structural concrete overpacks rather than ISO freight containers. These measures should ensure that cap settlement will occur to a much lesser extent and in a more gradual, controlled manner.

Other measures that are being considered include:

- the use of deeper vaults founded entirely on engineered clay (the effectiveness of such materials having been demonstrated in support of its use under some areas of Vault 8);
- maintenance free vertical drains which would route leachate direct to the regional aquifer, which is known to discharge to sea below the low tide line;
- an alternative permanent capping scheme involving the use of ridges of clay rather than a single dome; this would minimise the volumes of fill that would have to be imported for cap construction, and would significantly reduce the visual impact of the completed cap.

Firm decisions on these issues have yet to be taken on the basis of more detailed consideration of the technical feasibility and regulatory/public acceptability. Comparative risk assessments have already shown that vertical drains in particular may be beneficial. Figure 2 shows an artists impression of the net effect of the range of potential future developments.

DRIGG TECHNICAL DEVELOPMENT PROGRAM

The ongoing development of the Drigg Site is underwritten by a comprehensive technical support program which currently totals some £1.6M ($2.4M). The program is divided into three main areas namely engineering studies, near field studies, and far field/radiological studies.

These are considered in turn below.

Engineering Studies: Hitherto, the Engineering Studies Program has focused on comparative evaluation of the range of options available for the overall Engineering Development of the Drigg Site. Particular attention was focused on the interaction of the various options for waste treatment and packaging; vault design, operation, and closure; and leachate management. More recently, however, with the firming up of the compaction and packaging strategy, the emphasis of the program has shifted towards examination of more specific elements of the overall system. The principal issues currently being addressed are:

- the means by which suitable Sellafield waste can be loaded into $1m^3$ boxes for interim storage (the evidence being that there is insufficient space in the last open cut trench to accommodate all Sellafield waste that will arise during the period up to HFC plant availability);
- the options for packaging larger items of waste that will not readily fit into $1m^3$ boxes;
- the impact of the revised package specification on non-Sellafield consignors;
- design and testing of the $1m^3$ box;
- design and testing of the overpack;
- the options for dealing with the backlog of "high voidage" ISO freight containers that will have accumulated in Vault 8.

Near Field Studies: The near field describes that part of the ecosystem that has been influenced by disposal operations. It is comprised of a number of components including the waste itself, caps and cut off walls, repository walls, waste containers, backfill, engineered clay barriers and natural geological strata whose physical and chemical properties have been modified by other components of the near field.

The main aims of the program are to generate:

- source terms for gaseous and liquid material passing from the near field to the far field and biosphere. These terms will reflect both the radionuclide content of the effluents and their chemical characteristics;

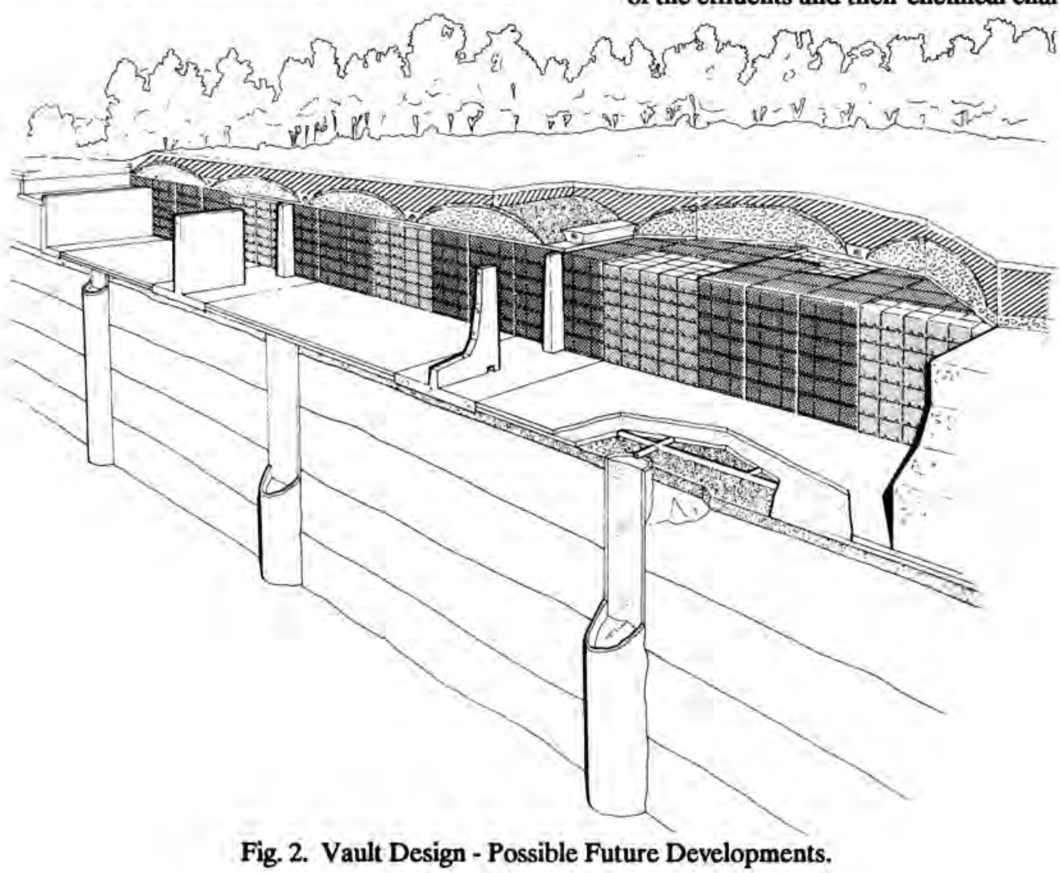

Fig. 2. Vault Design - Possible Future Developments.

- information on the characteristics of the solid residues remaining as the site reaches a chemically quiescent phase.

Specific areas of the near field program include:

- waste characterisation;
- waste degradation and gas generation;
- waste leaching;
- materials ageing;
- sorption properties.

Many aspects of these areas are also being brought together in a computer model of the near field, which incorporates both flow and physical/chemical interactions.

Far Field/Radiological Studies: The Far Field Program is aimed at understanding the migration of activity through the undisturbed geology at Drigg and ultimately into the biosphere. The main features of the program are hydrogeological characterisation, sorption studies and biosphere characterisation.

Hydrogeological characteriaztion involves a comprehensive program of field measurements aimed at understanding the site water balance, in conjunction with the development of computer models of both the perched and regional aquifers.

The main emphasis of the sorption studies program is on the development of techniques for characterising the sorptive capacity of the various sands and clays at Drigg. Biosphere characterisation involves surveying the soil and vegetation of the site and surrounding areas.

The data generated by the far field studies are used in radiological studies. The main feature of the radiological studies is the development of a site specific risk assessment methodology and database. A 3-dimensional network approach has been adopted for the geosphere component of the model, with a separate compartmental approach to modelling of the biosphere. Consideration has also been given to improving assessment of human intrusion scenarios, based on more explicit recognition of all events and failures necessary prior to intrusion occurring.

CONCLUSION

A range of improvements, particularly in terms of visual impact, have been made at Drigg. Out of operational necessity, however, these improvements have taken place over a relatively short timescale and work continues with a view to further optimising the overall system. Work is also in hand to further improve the understanding of the site's geology and hydrogeology and to develop a suite of computer models and supporting databases with the overall aim of creating a site specific risk assessment methodology.