

## Issues in UK cleanup and decommissioning; a strategic R&D programme

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### ABSTRACT

Nexia Solutions is contracted to manage and carry out research on behalf of the Nuclear Decommissioning Authority (NDA). This paper will describe the nuclear research ongoing and how it fits in with the [UK cleanup and decommissioning](#) strategy.

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The aim of the [strategic R&D programme](#) is to assist the NDA in maintaining a technical portfolio which will:-

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- identify and address challenges and clean-up problems that do not have an existing solution
- resolve potential inconsistencies between sites in the technical bases for certain strategic decisions and their implementation
- maintain options while developing strategy (emerging risks)
- save costs by developing multi-site solutions
- provide technology, skills and facilities on the timescale required

The strategy for the [R&D programme](#) has been developed from a top-level approach by understanding the challenges which need to be addressed and prioritising these according to the objectives of the [programme](#). The [programme](#) has demonstrated that a technical portfolio comprising six areas, each containing a number of key themes, is appropriate to address the technical challenges which the NDA faces and aligns with the NDA's technical issues register.

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An important aspect of the [R&D programme](#) is that it should create opportunities for undertaking the NDA mission more effectively. This arises from the emphasis given in those technical programmes which define the challenge more precisely and thus provide a platform from which to produce innovative solutions.

The paper will present an overview of the [strategic R&D programme](#) along with the key [technical](#) programme areas. Examples will be provided of the technical work ongoing, and the results obtained so far.

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## INTRODUCTION

Within the UK, dealing with the nuclear waste legacy is a major activity requiring significant research and development to support the Nuclear Decommissioning Authority (NDA) in carrying out its overall mission. The NDA has the remit, as set out within the Energy Act, to 'promote, and where necessary fund, research relevant to nuclear clean up'. To deliver this remit, the NDA has generated Life Time Plans (LTP) that ~~includes~~ the proposed technical baseline underpinning required. These were then consolidated into the published R&D Needs, Risks and Opportunities [ref 1] required by the NDA to deliver the LTP. A strategy was then developed for a ~~R&D programme~~ that would manage and deliver a technical portfolio of work aligned against the R&D Needs, Risks and Opportunities.

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~~Nexia Solutions is the~~ UK's key centre for nuclear fuel cycle research, and ~~has been~~ declared by HM UK Government in October 2006 as the base for the National Nuclear Laboratory (NNL). ~~With the announcement of the NNL, the Government has signalled its commitment to protect the UK's national nuclear technology capability. Nexia Solutions is already supporting that commitment by employing a strategy that proactively sustains and develops nuclear technology skills to deliver for customers and maintain capabilities of strategic national importance. This strategy will develop further with the establishment of the NNL.~~

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## OVERVIEW OF THE RESEARCH CONTRACT

The aim of the strategy for the R&D programme is to assist the NDA in maintaining a technical Portfolio which will:-

- identify challenges and clean-up problems that do not have an existing solution
- resolve potential inconsistencies between sites in the technical bases for certain strategic decisions and their implementation
- maintain options while developing strategy (emerging risks)
- save costs by developing multi-site solutions
- provide technology, skills and facilities on the timescale required

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The strategy for the R&D programme has been developed from a top-level approach by understanding the challenges which needs to be addressed and prioritising these according to the objectives of the programme. The R&D programme has demonstrated that a technical portfolio, comprising the areas listed below, is appropriate to address the technical challenges which the NDA faces and aligns with the NDA's technical issues register.

- Low Level Wastes (LLW)
- Intermediate Level Wastes (ILW)
- Nuclear Materials Management
- Site End Point Management
- Decommissioning Engineering & Plant Termination
- Skills and Capability

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The programmes cover the full span of the NDA mission because it is recognised that the later aspects of decommissioning and site clean-up set goals for the earlier phases of waste retrieval, conditioning and storage. The overarching programme of skills & capability spans the entire timescale of the NDA mission.

Five of the research priorities considered (not in order) are:-

- High level & intermediate level wastes and spent fuel
- High volume, low activity wastes
- Nuclear materials management
- Rate and pace of decommissioning
- Site End Points

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The R&D programme aligns with these NDA priorities. An important aspect of the programme is that it should create opportunities for undertaking the NDA mission more effectively. This will arise from the emphasis given in those technical programmes which define the challenge more precisely and thus provide a platform from which to produce innovative solutions. Ongoing dialogue and communication with the NDA's Site Licence Companies (SLCs) is a key aspect of all of the technical programmes.

The overall aim is to provide the NDA with options to:-

- Reduce uncertainty
- Accelerate clean-up/decommissioning
- Reduce lifetime costs
- Reduce hazards and risks

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By doing this, the programme provides an input to the development of NDA strategy or policy, makes a significant contribution to skills maintenance or development, and develops technologies with the potential to improve the overall delivery of the mission.

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## KEY PROGRAMMES

The strategy for the R&D programme has been to manage the technical Portfolio comprising six areas listed below, each containing a number of key themes, and these have addressed the technical challenges which the NDA faces and aligns with the NDA's technical issues register.

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Programme	Themes
LLW	Develop strategy – stakeholder liaison, enable integration / synergies, identify gaps Manage data – to establish and evaluate waste inventory Enhance data – tools to establish and enhance sampling and characterisation Best practice / skills availability
ILW	Evaluation of alternative cement systems. Characterisation of cement systems, including water phases
Nuclear Materials Management	Management of wastes and residue Characterisation of spent fuel and waste feeds Spent fuel and waste treatment Interim safe storage of wastes, plutonium Direct waste disposal or re-use Transport and packaging
Site End Point Management	Site end point strategy – stakeholder needs, contaminated site network, enable integration, option development, identify gaps Tools – to enable the assessment and comparison of options Site characterisation – to provide data and robust understanding to enable option assessment Best practice / skills availability
Decommissioning Engineering & Plant Termination	Improved characterisation of defunct facilities Intractable wastes - multi-site Generic decommissioning solutions
Skills and Capability	Maintenance of the UK nuclear skills base

## LLW

The LLW management strategy is being developed through consideration of predicted LLW inventories with respect to existing and potential future LLW disposal repositories. Through the Waste Categorisation project, there is a focus on the minimisation, re-use, etc, of wastes (and LLW in particular, due to the large forecasted volumes) as the sites move forward into decommissioning activities, since there are significant potential savings that could be achieved with the timely application of technology already in existence.

## ILW

ILW is present on most NDA sites, and only the minority of the lifetime arising has already been packaged for eventual disposal. There is no long term management arrangement yet available and hence issues are associated with whether the ILW should be continued to be stored in-situ or in a designated interim storage facility. There are a wide range of radioactive materials which need characterisation if appropriate treatment, package, storage and disposal solutions are to be adopted. Some sites have small volumes of well characterised stable wastes while others, notably Sellafield has large volumes of poorly characterised wastes with varying amounts of hazards. Increasing the knowledge of radioactive material usually yields considerable benefits for the selection of treatment options. There are four key steps which have to be addressed in the management of ILW (retrieval, processing, packaging and storage) and each stage has a range of challenges. Processing is needed to enable waste to be packaged safely for interim storage or disposal. Historically low energy and low temperature processes are preferred, however alternative higher temperature options may offer advantages of increased versatility, waste minimisation and a more stable waste form. There is potential for substantial savings for management of ILW at NDA sites by following a similar strategy to that proposed for LLW. Work is focus on sites with common ILW. Similarly the use of common waste processing plants such as grouting promotes efficient use of resources.

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## Nuclear Materials Management

The UK inventory of separated civil plutonium is expected to exceed 100 tonnes by 2010. Programmes of work are in progress to evaluate both the potential for use, in the manufacture of MOX fuel in future power generation scenarios, and potential technology for the disposal of surplus plutonium. Nexia Solutions is undertaking this evaluation on behalf of the NDA, and is considering both the options of re-use in the current reactor fleet, and immobilisation as waste. Immobilisation would be achieved by assimilation of the plutonium into a durable host matrix followed by long term storage and subsequent final repository disposal.

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<#>Immobilisation Science Laboratory¶  
<#>Evaluation of alternative cement systems¶  
<#>Evaluation of superplasticisers¶  
<#>Water phases in cement¶  
<#>Evaluation of waste / simulant samples for archiving¶

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## Site End Point Management

The determination by SLCs of appropriate and robust end points (and end states) for sites is intimately linked to the NDA's drive for accelerated timescales for decommissioning. Although site closure or delicensing may be decades away for many sites, it is important to explore early the alternative options for clean-up since these have potential impact on the end points (or 'interim' end points). The issues addressed within the site end point management programme apply to contaminated land, existing and potential future near-surface disposal facilities, and concepts such as on-site disposal. To an appropriate level of consistency and of detail - that is in turn dependent on the complexity of each site - the NDA sites need to be: characterised; assessed with respect to radiological and non-radiological impact from existing contamination; and assessed in comparison to the impact from alternative end-states that would arise from remedial actions. Key benefits from addressing these issues will be reduced uncertainties in costs and in technical considerations. The important issues can be organised for convenience under projects within the technical 'themes' of: tools and codes; site characterisation and data; and assessment approach.

## Decommissioning Engineering & Plant Termination

The decommissioning and plant termination of facilities is the ultimate objective for the NDA mission. Support thru the R&D programme is provided in two areas; generic decommissioning solutions and improved characterisation and prioritisation of defunct facilities. Contaminated concretes and metals from plant operations over a number of years are projected to constitute one of the largest fractions of UK nuclear waste by volume. Frequently, contamination is adhering to structures or equipment with complex geometries and in many instances residual activity levels are high enough that human exposure during decommissioning and disassembly activities represents an unacceptable risk. Developments in generic decommissioning and plant termination solutions that address the reduction of risks are key to reducing the cost and schedule to the NDA of these activities. In addition, to support its decision making the NDA requires a prioritisation process which considers a range of factors which are key to delivering the NDA's mission of "safe, cost-effective, accelerated and environmentally responsible decommissioning of the UK's civil nuclear legacy in an open and transparent manner and with due regard to the socio-economic impacts on our communities".

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### Skills and Capability

This project is enabling the UK to sustain skills and capabilities, predominantly in experimental transuranic chemistry. Progress is being made in the integration of the key industrial and academic skill bases and these skill bases are being developed in to new fields of actinide chemistry related to the clean up of UK legacy wastes.

One aspect of the work is focused on investigating a few significant issues that will affect the behaviour of the transuranic species during the retrievals, processing and waste management steps involved in legacy pond clean up activities. Currently, the focus is on development of methods and techniques that can be used by SLCs to characterise actinide ions in real pond /sludge samples, e.g. particle size, activity fractionation, SEM, Pu speciation, and also the development of time-resolved-laser-fluorescence for fundamental actinide and lanthanide speciation studies in waste and environmental matrices. This is a new focus for our actinide chemistry skill base and hence developing expertise in this area is highly relevant to the NDA's clean up mission and is a priority.

Another aspect of the work is concerned with maintaining core skills in fuel processing and separations chemistry by developing and underpinning advanced flowsheets suitable for application to UK spent fuel, legacy fuels and residues processing, including maintaining involvement in the European framework programme.

## KEY SUCCESSES OF THE R&D PROGRAMME

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The R&D programme has delivered a large number of successes over the years it has been operating. These successes allow the NDA to develop strategy or policy, make a significant contribution to skills maintenance or development, and develop technologies with the potential to improve the overall deliver of the NDA's mission. Some of these successes are detailed over the following pages.

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### University Research Alliances (skills)

The University Research Alliances (URAs) were developed by British Nuclear Fuels Limited (BNFL) to gain access to academic expertise but in a way which is appropriately focused on the needs of the nuclear industry. The R&D programme contains projects to build and sustain 5 URAs. The URAs are included in different technical programme areas, as seems most appropriate, although they are difficult to pigeonhole because of their multi-disciplinary & multi-issue nature.

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All the URA's have science plans which are focused on NDA R&D needs and have shown real benefits in terms of the research undertaken. The nature of the URAs is enabling access to other research funding so that the NDA is benefiting from significant leverage of funding. All of the URA's have been very successful in attracting industry and research council funding. It follows that the investment in the infrastructure of the URA, even beyond their initial 5 year contract, is an effective use of resources while such leverage can be maintained. Continued funding enables the NDA to maintain the focus of the centres in research areas of relevance to the NDA's mission.

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### PhD Bursary (Skills)

For the last 2 years of the Research Contract, the NDA has provided a bursary fund to provide sponsorship for PhD's in support of the NDA's mission. Appropriate evaluation criteria have been identified in conjunction with NDA. These include, but may not be limited to criteria such as:

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- the potential impact on future decommissioning and clean-up activities
- the existence of an effective means of communicating the results to NDA
- value for money / cost effectiveness
- socio economic benefit in the region of NDA sites
- the degree of innovation proposed

This work aligns to the NDA objectives of skills development & maintenance, and carrying out and promoting research into decommissioning and clean-up. Successful research programmes carried out by PhD and EngDoc students have the potential to generate value for the NDA. By sponsoring relevant research programmes the NDA are also contributing to the development of a pool of researchers with skills of relevance to the NDA. This is one of the components of a strategy to ensure the availability of a suitably skilled workforce. Research topics supported are chosen to maximise the potential financial benefit in the event that the research is successful. In addition they make a contribution to the development and maintenance of the skills required for the NDA to discharge its mission.

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To date, funding for 15 PhD's at a variety of UK universities has been allocated through this bursary fund.

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## Alternative cements (ILW)

The immobilisation of reactive metals such as Al, Mg and U is a challenge faced by a number of NDA sites. These all continue to corrode to some degree in the standard Ordinary Portland Cement (OPC) based grouts generally used on NDA sites. A project has evaluated alternative cement systems to determine the potential for their use in the safe encapsulation of reactive metals. The target was to identify systems in which these metals are far less susceptible to corrosion. Based on expected hydration chemistry, potential chemical compatibility with wastes such as reactive metals and ion exchange materials, proven track record in civil construction, availability of raw materials, and quality standards, the following alternative cement systems for treating potentially problematic waste were proposed as meriting further study:

- calcium sulfoaluminate
- magnesium phosphate
- sulphate-activated blast furnace slag
- supersulfated cement

The output from this phase of work was enthusiastically supported by a wide range of stakeholders. Continuation of this work will enable the immobilisation of a number of waste streams to be carried out safely and without concern. This would result in the delivery of technologies to enable the immobilisation of certain waste streams for which no practical solution is currently available. It may enable these materials to be encapsulated at much higher waste loadings, thus reducing waste volumes and immobilisation and disposal costs of several £k per m3 of volume reduction.

### Prioritisation (Decommissioning)

With the responsibility for the clean-up of the UK's civil nuclear liabilities becoming centralised with the Nuclear Decommissioning Authority (NDA), there is now the opportunity to take a strategic view of the challenges posed by decommissioning at a national level. In particular, this enables prioritisation of activities in a way which maximises the benefit to the UK. To support its decision making, the NDA initiated the formation of a team including a number of stakeholders to develop a prioritisation process which considers a range of factors which are key to delivering the NDA's mission of "safe, cost-effective, accelerated and environmentally responsible decommissioning of the UK's civil nuclear legacy in an open and transparent manner and with due regard to the socio-economic impacts on our communities".

The NDA prioritisation process provides a single process which allows consistent assessment of UK nuclear clean-up projects so enabling the development of a prioritised list of these projects. The prioritisation process also provides a mechanism through which progress of clean-up can be demonstrated. It is important that the prioritisation process can be simply and consistently applied across all the NDA facilities and that the process is simple enough to be used to consider potential alternative clean-up scenarios. In particular, the prioritisation process considers the hazard potential of stored materials and the ongoing environmental impact of facilities. All other things being equal, plants with a significant hazard potential and environmental impact would be scheduled for clean-up before those with a lesser hazard potential and environmental impact.

The hazard potential used in the prioritisation process has been divided into two parts, radiological hazard potential and chemical hazard potential.

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¶ The alternatives for the disposition of the UK's civil plutonium stocks are currently being investigated by Nexia Solutions Ltd. on behalf of the NDA. A number of scenarios are currently being considered depending on the strategic requirements of the UK. The two main disposition options are: re-use as MOX (Mixed Oxide) fuel in reactors as originally envisaged, or immobilisation in the event of any material being declared surplus to requirements. The amount of Pu which will require immobilisation will depend on future UK nuclear strategy, along with the extent of any stocks deemed unsuitable for re-use. However, it is likely that some portion will have to be immobilised and therefore three credible wasteforms are under consideration; ceramic, glass and 'immobilisation' MOX. 'Immobilisation' MOX would comprise MOX fuel pellets manufactured 'as normal', with the exception that the dimensional tolerances required of reactor operations could be relaxed. These are currently being developed and assessed in a systematic programme that involves periodic evaluation against a range of criteria. In this way, by down-selecting on the basis of robust and technical review, the best option for immobilising surplus civil plutonium in the UK can be recommended to the NDA. The latest results from the immobilisation experimental programme are presented in the following paper at Waste Management 2008. Progress in the Assessment of Wasteforms for the Immobilisation of UK Civil Plutonium – 8241, M.T. Harrison, C.R. Scales, and E.R. Maddrell.¶

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Radiological hazard potential is based on consideration of the quantity of water that would be required to dilute the inventory so that a population drinking the resulting solution would not exceed its annual limit on intake, even if this was their sole source of water. This quantity was then refined to further consider the mobility of the material and the control measures required to maintain the inventory in a safe storage state. For example, solids which require infrequent inspection to guarantee safe storage have a lower hazard potential than liquids which must be continually cooled for safe storage. Chemical hazard potential was based around the COMAH limits used to assess major hazards, extended to encompass less hazardous substances. Mobility and control measures were considered in the same way as in assessments of the radiological hazard potential. An equivalence between radiological and chemical hazards was made on the basis of the dilution required to reduced hazardous chemicals to their drinking water limit.

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Environmental impact in the prioritisation process had to balance a wide range of potential aspects: radiological discharges, non-radiological discharges, use of resources such as power and water as well as visual impact of plants and the impact on wildlife. This would potentially result in very complex assessments that would not be compatible with the goal of producing a simple system. The EU Externalities of Energy project established monetary costs of many environmental impacts resulting from the lifecycle of various methods of power generation and this work was reviewed and it was found that there were opportunities for NDA to make use of the work to express the various environmental impacts arising from nuclear facilities in a common, monetary, unit. When this was done, it was found that the dominant impact of plants in a regime of care-and-maintenance was the indirect discharges resulting from the use of electricity within the facilities. This was initially unexpected, but indicates that the industry operates with well-regulated direct discharges that have only small impacts. As a result of this finding the electrical usage of each facility was taken to be a measure of the dominant environmental impact arising due to the continued presence of a facility.

The environmental impact and hazard potential then had to be compared in order to obtain a single prioritisation measure. This was done by a panel that compared a range of facilities with different environmental impacts and hazard potentials. A weight for the environmental impact was found which gave best agreement with the panel's intuition of the relative priority of decommissioning of the facilities.

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Certain impacts, such as visual intrusion of facilities, are not considered by this process because they are dependent on the particular site at which they are assessed. The NDA prioritisation process allows the ranking to be modified to reflect stakeholder issues such as this. The key requirement is that modification of the ranking is clearly recorded and is subject to NDA audit in order to establish consistency across the UK.

A prioritisation process which supports the NDA's mission has been developed. The prioritisation process has now been deployed across all UK civil nuclear sites and can be used by site licensees to enhance their proposed work programmes to better deliver the NDA requirements. The process also defines a measure which can be used to demonstrate progress against the NDA's goals.

## Waste characterisation and categorisation (LLW)

The potential cost benefits arising from the analysis of waste categorisation practices are being demonstrated on the order of £1M's to 10M's per site for a project cost of a few £10k's per site. All NDA sites have been assessed during FY06/07 and 07/08 for combinations of prevention, reuse / recycle, decontaminate / concentrate, size reduction and pack preparation of compactable and non-compactable LLW arising. For example, analyses of one site has enabled the site management to revise their plans, reducing the processing costs for LLW of c.£36M to around £25M by adopting recommendations to increase the packing efficiency from 20% to 40%.

### ReCLAIM (Site end point management)

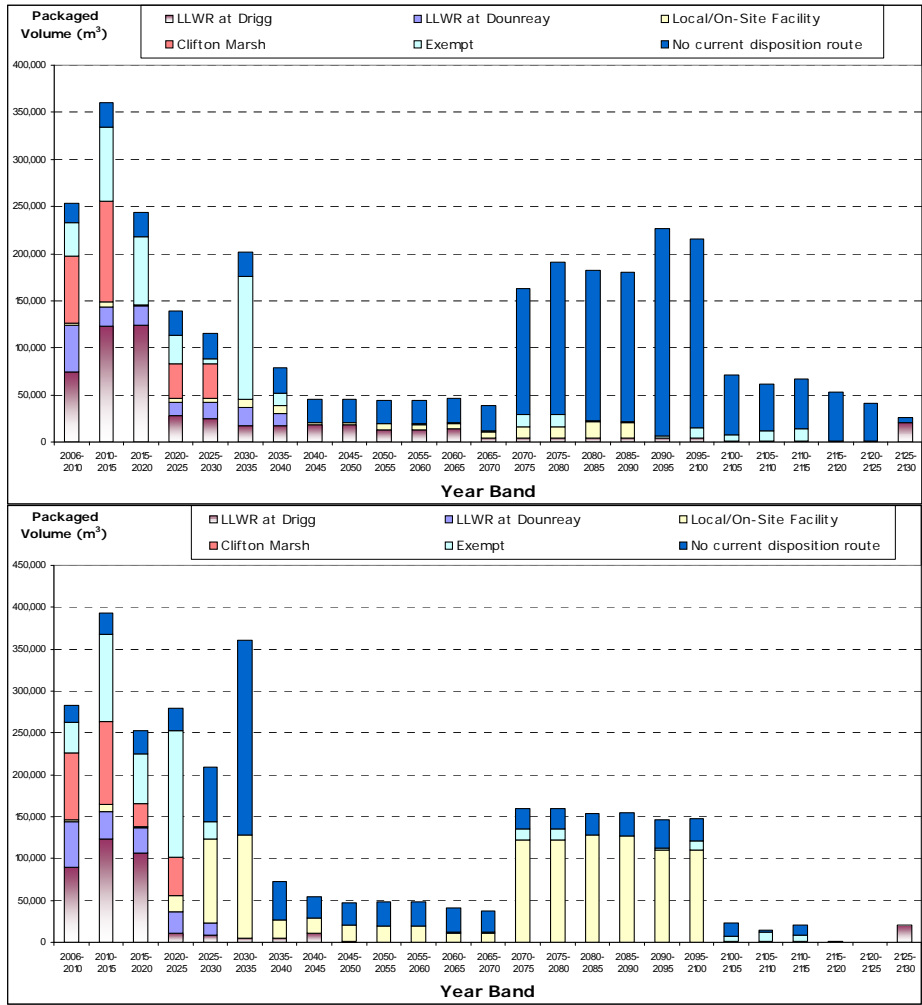
Version 2 of the ReCLAIM (review of contaminant levels for assessment of de minimus inventory model) tool - with accompanying documentation - for identification of potential problems due to contaminated land has been released to SLCs and others through Nexia Solutions web site (<http://www.nexasolutions.com/reclaim>). The ReCLAIM tool has been reviewed successfully by UK Health Protection Agency and UKAEA technical representatives. 'Hands-on' practical training workshops on ReCLAIM have been provided to SLC and NDA representatives. Further information can be found in references [ref 2, ref 3].

### LLW management strategy (LLW)

The WIDRAM (Waste Inventory Disposition Route Assessment Model) database has been successfully developed, with positive buy-in from representatives of key nuclear industry organisations (e.g. NDA, incl. ex-Nirex, Sellafield Ltd). The functionality of WIDRAM enables the user to more easily create and modify LLW disposal scenarios, to split waste streams by physical properties to allow for modelling of the NDA's reuse/recycling targets, and has greater emphasis on disposal sites other than the LLWR at Drigg. Further information can be found in the following paper at Waste Management 2008. 'Development Of Strategy For The Management Of LLW In The United Kingdom'. A Wareing and J Fisher.

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Figure 1: Understanding LLW arisings, and restrictions at LLWR site, leads to the generation of LLW disposition strategies using WIDRAM: [top] Scenario 1: Current practice, & [bottom] Scenario 2: Accelerated decommissioning programme (with packaged volumes by disposition route)



## SimER (Site end point management)

The SimER (Simulation of Environmental Risks) code is available for use via the Nexia Solutions website (<http://www.nexasolutions.com/simer>). SimER is a powerful and flexible performance assessment code for contaminated land and near-surface waste disposal sites that has been developed by Nexia Solutions through support from the NDA. SimER can be used to support decision-making on site end states and management strategies for sites at a level consistent with regulatory submissions.

Capabilities and applications provided by SimER include:

- 3D groundwater flow (saturated and unsaturated conditions) and contaminant transport (radioactive and non-radioactive);
- representation of topological details and geological structures;
- explicit climate and landscape change representation;
- 3D modelling of engineering and remediation options for contaminated land and waste disposal sites;
- assessment-level representation of the physical and chemical properties of the system; and
- calculation of a wide range of impacts such as environmental concentrations and doses/risks to exposure groups over time.

Pertinent features of SimER include:

- flexible inventories component - for contaminated land or a variety of waste forms emplaced at different times;
- multiple run capability allowing sensitivity studies and probabilistic assessments;
- flexible input language including unit checking; and
- built-in visualisation capability to display 3D views of model output and plot graphs of parameters against time.

A paper on the capabilities of the SimER tool was presented at the WM07 conference in Tucson [ref 4].

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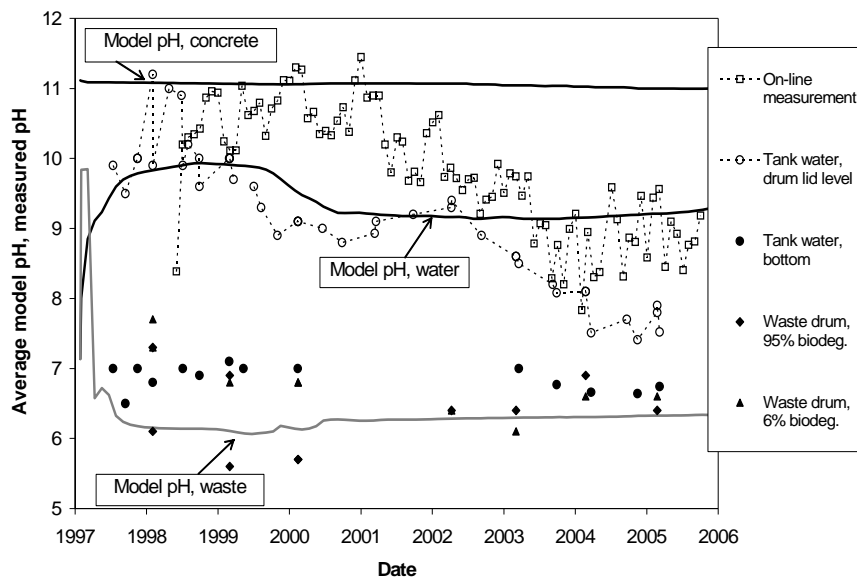
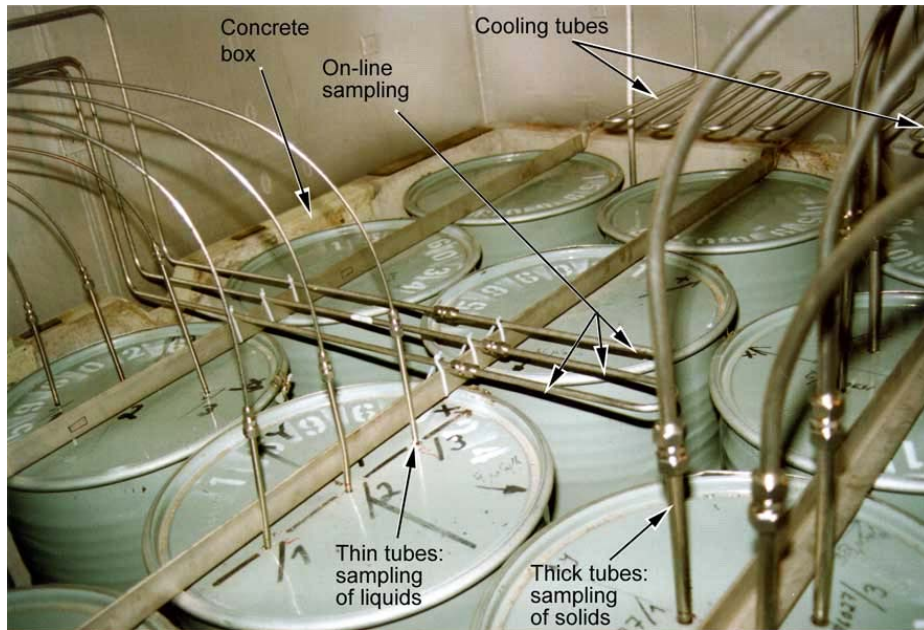
## Models to characterise the behaviour of radionuclides and reactive chemistry and transport properties of contaminated land and waste disposal sites (Site end point management)

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The NDA has recognised the clear benefit and application to the NDA's geological disposal programme of the Reactive Radionuclide Transport Modelling project's collaborative work with TVO (Finland) - on the verification of biogeochemical models of gas generation in repositories. Further work to review data inputs and to identify a verification data set for the NDA's Simplified Model of Gas Generation (SMOGG) is now in progress.

A final version of a significant paper on "Experimental and modeling investigations of the biogeochemistry of gas production from low and intermediate level radioactive waste" - written in collaboration with TVO, Finland - has been accepted for publication by the journal *Applied Geochemistry* (Experimental and modelling investigations of the biogeochemistry of gas production from low and intermediate level radioactive waste. J Small, M Nykyri, M Helin, U Hovi, T Sarlin, and M Itävaara).

| Figure 2: Collaboration with TVO Finland on experiments and modelling of gas generation



## LEADERSHIP AND MANAGEMENT OF THE R&D PROGRAMME

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### Project Management

Nexia Solutions is a project centric business, with all work for customers being delivered through the project management function. The project management function is accountable for delivery of the work to the customers to time, cost and quality. The R&D programme is managed as a single portfolio of work by a dedicated project manager with a team of project engineers responsible for individual programme areas. Normal project management performance measures are utilised to manage the portfolio and monitor variance. All projects have baseline project plans which are used to provide the variance analysis required to control and monitor performance.

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### Technical Leadership

Nexia Solutions has recognised the importance of technical quality and the need to provide clear technical leadership when delivering projects and programmes in a commercial environment and so we have implemented a new structure within the company that provides technical assurance through a series of Authorities and Leads.

Technical Authorities have an oversight role for their given subject area for the all projects and programmes, from initial scoping through to final delivery. For example, the Technical Authority for Nuclear Materials has oversight of the Civil Pu disposition project within the R&D programme described above, as well as projects on storage and waste treatment carried for other customers such as Sellafield Sites and AWE plc. This gives the Technical Authority a unique advantage to see the connections that ensures we are able to provide the best solutions to the customer and our full capabilities and expertise is utilised in delivery.

For each project within Nexia Solutions, a Technical Lead has been assigned (through the Technical Authority) who provides oversight of all the technical issues, directs the technical work and approves all the output. This gives dedicated technical leadership to support the specific needs of the customer, project and project management team.

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<#>Defining the technical approach and strategy during initial scoping of a project or programme¶  
<#>Ensuring the technical approach and quality is maintained during the delivery phase¶  
<#>Technical outputs from the projects or programmes meet customers' needs¶  
¶  
The technical authorities hold a key role in supporting the project management team in providing technical leadership to meet customer needs. ¶

### SUMMARY

The results generated by work carried out under the strategic R&D programme have identified a number of opportunities to add value or adopt more efficient technologies.

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An important aspect of the programme is that it should create opportunities for undertaking the NDA mission more effectively. This arises from the emphasis given in those technical programmes which define the challenge more precisely and thus provide a platform from which to produce innovative solutions. The NDA have highlighted the progress made to date on the R&D programme, and how it aligns against its mission in its annual report and accounts, section Innovation, skills, R&D and good practice [ref 5].

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A number of examples from current work programmes have been provided that demonstrate the range of work undertaken in the R&D programme, along with the value it provides directly in meeting the

NDA's mission. Through the R&D programme, the work provides an input to the development of NDA strategy or policy, make a significant contribution to skills maintenance or development, and develop technologies with the potential to improve the overall deliver of the mission.

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## **ACKNOWLEDGEMENT**

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