NDA
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Magnox South

Magnox South

2008/09 Lifetime Plan Supporting Volume

Technical Baseline and Underpinning Research & Development

Site Strategy Information **SI.2A**

TITLE: Technical Baseline and Research & Development Document for Bradwell Decommissioning Site, Lifetime Plan 2008/2009.

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I confirm that this document has been subject to review and verification within Magnox South.

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ISSUE: **…………………………………… DATE:……………**

Greg Debner, Director of Engineering, Waste, Strategy & Technical, EWS&T.

Revision Register

Revision Ref	**Date**	**Author**	**Reason**
Issue 1	01 Feb 2007	S A Coupe	New issue
Issue 2	12 Feb 2007	S A Coupe	Updated with comments from Greg Debner
Issue 3	14 March 2007	B. Ladd	Updated Wiring Diagrams
	05 November 2007	S Coupe	Red lined for LTP2.1
	13 November 2007	J Gardner	Addition of generic information
Issue 4	05 March 2008	S A Coupe	New issue for LTP08

Contents

1 Introduction

This section of the Lifetime Plan (LTP) submission, the Technical Baseline and Research and Development (TBRD) document is to provide an overview of the Bradwell Decommissioning Site technical baseline and research and development work that supports the approach to decommissioning for the remainder of the site's lifecycle.

As part of Magnox South reactor sites, Bradwell Decommissioning Site is now engaged in decommissioning and cleanup activities with the site's remaining lifecycle described in the TBRD document in four phases:

- De-fuelling – completed at Bradwell Decommissioning Site
- Care & Maintenance Preparations (C&M Preps)
- Care & Maintenance (C&M)
- Final Site Clearance (FSC) and re-use.

1.1 Approach to Decommissioning

Magnox Electric Ltd, as the Site License Company (SLC) operating the Magnox South nuclear licensed sites, including Bradwell Decommissioning Site is responsible for developing and implementing decommissioning and waste management strategies consistent with the requirements and overall national strategy of the Nuclear Decommissioning Authority (NDA) (Ref 1) and in accordance with relevant Government policies.

This TBRD document represents the Bradwell, site specific implementation of the current strategy agreed by Magnox Electric Ltd Board for the Magnox business. Work will also be carried out with the Decommissioning Strategy Organisation (DSO), which has been established in Magnox South to carry out research and development work on key waste management and decommissioning issues. The output of this work will underpin and further develop the current technical baseline strategies to be implemented at Bradwell Decommissioning Site.

1.1.1 Decommissioning Principles

The following principles guide development of Magnox Electric's strategies and plans for decommissioning and waste management that are subsequently implemented at the sites including Bradwell:

- The safety of the public and the workforce, together with protection of the environment, are of paramount importance and will be considered ahead of all other factors.

- Strategies will be compliant with legislation, be in accordance with Government, NDA and Company policy, and take due account of stakeholder views and regulatory and industry guidance.

- The priority associated with Decommissioning and Waste Management Strategies will be informed through evaluation of current Safety and Environment Detriment values and the future reduction of these carried out in line with the NDA prioritisation process.

- Preferred strategies will be identified in a systematic, consistent and auditable manner using best available scientific, engineering and economic knowledge and taking account of socio-economic and political factors, risk and uncertainty. A wide range of options will be considered. The results of stakeholder engagement will be fed into the decision-making process.

- Strategies will maintain a flexible approach so as not prematurely to foreclose options, thereby maximising the capability to accommodate changes related to, for example, technical and regulatory developments or waste repository availability. However, all strategies will have a clearly identified exit route that is currently capable of implementation.

- Strategies and plans will be regularly reviewed to ensure they remain fit for purpose, learning from experience and taking account of emerging technologies through a continuing Research and Development programme.

- Strategies, plans, processes and technologies will deliver value for money for the liability owner over the remaining lifetime of the reactor sites.

- The quantities of radioactive and otherwise hazardous waste arising during the course of decommissioning will be minimised, as far as reasonably practicable.

- Radioactive waste for which there is no currently available, appropriate disposal route will be placed into a passively safe state. Where it is appropriate to package this waste, it will be placed in a form suitable for interim surface storage consistent with the requirements of the relevant disposal organisation.

- Throughout any decommissioning deferral period the sites, including any remaining radioactive waste, will be managed to maintain a passively safe state that minimises the need for control and safety systems, maintenance, monitoring and human intervention.

- Where any decommissioning or waste management work is to be deferred, appropriate knowledge and records will be retained and maintained throughout the period.

1.1.2 Main Objectives

The approach to decommissioning at Bradwell has been aligned with Magnox Electric Ltd’s key objectives in development and implementation of decommissioning and waste management strategies, which is to:

- Ensure the continued safety of the public, the workforce and the protection of the environment.

- Deliver systematic and progressive reduction of hazards on-site.

- Achieve an appropriate balance in the use of environmental, social and economic resources both now and in the future.

- Clear and de-license the site or to achieve other such end state as agreed.

Bradwell site has developed their detailed TBRD in accordance with the Company's waste management and decommissioning strategy. This is based on the submission to HSE for the quinquennial review (QQR) (Ref 3) in 2000. The QQR submission was updated in 2005 to a Company Standard (ref 5) agreed by the Magnox Electric Board in 2005. It was revised and re-issued in March 2007 and is subject to periodic review and update.

It is recognised that the Bradwell TBRD may not represent the optimum solution in some areas. Therefore the R&D proposals are expected to provide opportunities for acceleration and/or optimisation of the clean-up process. This approach is consistent with industry best practice and current technologies that also take account of stakeholder expectations.

1.2 Current Status

Bradwell ceased generation in March 2002 and provided final confirmation of fuel off-site in October 2006, when the site moved into the Care and Maintenance Preparations phase (C&M Preps). During this phase, all major buildings with the exception of the two reactor buildings and the Intermediate Level Waste (ILW) Store, will be decontaminated and demolished. The end of this phase is currently scheduled for the end of March 2027, but this is under review to align with the current NDA decommissioning arrangements within Magnox South.

For the purposes of the technical baseline and decommissioning work, the Bradwell site layout can be considered in three main elements:

- Conventional area – containing non-radioactive plant and buildings (turbine hall, workshops and offices etc.)

- Radiological Controlled Area (RCA) – including a number of buildings with internal plant and structures that are contaminated with radioactive substances (e.g. cooling ponds, operational waste storage facilities, radioactive effluent treatment plant, active drains, laundry and workshops etc.)

- Two reactor buildings (also within the RCA) – each containing one nuclear reactor of the gas-cooled, graphite-moderated, Magnox type. Each reactor building also houses activated material within the quarter voids and storage areas. The material will remain in-situ until final site clearance.

This document expands on the current baseline for the technical approach to work that has already been planned and costed and on which the current plans are based. When opportunities are identified to improve the baseline in terms of cost, schedule, safety and the environment, these activities will also be included in the Research & Development section of the TBRD.

It should be noted that Bradwell is the lead site for the some of the generic waste management R&D initiatives managed by the Decommissioning Strategies Organisation within Magnox South with the aim of improving upon the current site baseline in terms of time and cost, safety & environmental impact. Such opportunities include enabling works for Fuel Element Debris (FED) volume reduction, minimisation of Wet ILW packages through process and formulation options for Ion Exchange (IX) resin, combined facilities for Wet and Solid ILW management and a simplified 'fit for purpose' interim ILW store to accommodate variable, and potentially dramatically reduced quantities of ILW waste packages, to meet future strategies.

The FED volume reduction opportunity for Dissolution is currently scoped within the Lifetime Plan and as appropriate, is being progressed through the development of the initial concept design through to a developed design. Those opportunities that have been optioneered and selected as the Best Practicable Environmental Option (BPEO), have undergone BPM studies and when they have received outline planning permission and Environment Agency approval will form the future basis of the LTP. It is anticipated that this decision will be made in financial year 2008/2009. If this decision is positive and FED dissolution becomes the baseline strategy, further opportunities will be explored, including the transfer of wet ILW material to a UK facility for immobilisation and interim storage. This would result in the simplification of the specification for on-site ILW immobilisation facilities and may entirely eliminate the requirement for an interim ILW store at Bradwell.

Technical work techniques are governed by environment, health and safety legislation and it is a given that all work undertaken will comply with the relevant regulations. Bradwell has a comprehensive infrastructure in place including independent verification to ensure high performance standards and that compliance with the requirements is maintained. Expert resource in these fields together with Core Competence, Design Authority, and Intelligent Customer capability is fully maintained. An overview of the work is given below:

1.2.1 C&M Preps Phase:

The site is now in the first stage of site decommissioning, C&M Preps, where all major buildings except the bio-shield in the two reactor buildings and a newly constructed Intermediate Level Waste (ILW) store will be removed from site. The remaining planned work for this phase includes the following:

- Completion of the construction of the LLW Management to satisfy the scheduled capacity required to process and despatch LLW arisings from the decommissioning activities.

- Pond Decommissioning associated works including modifications to the Ventilation system, draining of the Ponds, application of a surface sealant and scabbling of the internal surfaces to remove the contamination to a *de minimis* level.

- Ponds decommissioning including the final removal of contaminated equipment and material, decontamination of concrete surfaces, removal of the station process plants (Active Effluent Treatment Plant (AETP) and the Ponds Water Treatment Plant (PWTP)) to prepare the facility for final demolition.

- Installation of a mobile AETP and final site discharge route to enable active effluent, generated during final site POCO, decontamination and decommissioning activities, to be treated and discharged off-site.

- Installation of an operable fire suppression system during the retrieval of Fuel Element Debris (FED) material from the dry Active Waste Vaults (AWVs).

- The retrieval, processing and packaging of the accumulated operational Intermediate Level Wastes (ILW) that are currently stored within the purpose built Active Waste Vaults (AWV) on-site. The resulting packaged waste, which will then be promptly encapsulated/solidified in a combined Wet and Solid facility; to produce a passively safe wasteform, will be placed in an on-site store pending the availability of an off-site deep repository or alternative facility.

- The decontamination, deplanting and demolition of the buildings within the radiological controlled area (RCA), containing varying levels of contamination, which are external to the reactor buildings, including the Ponds complex, Active Waste Compound and Active Waste Handling Building (AWHB).

- Deplanting of all reactor building components and structures, back to the bio-shield. Boilers and contaminated primary gas circuits maintained in a lay-down state until disposal path options are established. Reactor building height reduction, after the removal of the charge face equipment, for the final Safestore preparations.

- The deplanting and demolition of the buildings within the non-reactor/conventional area of the site.

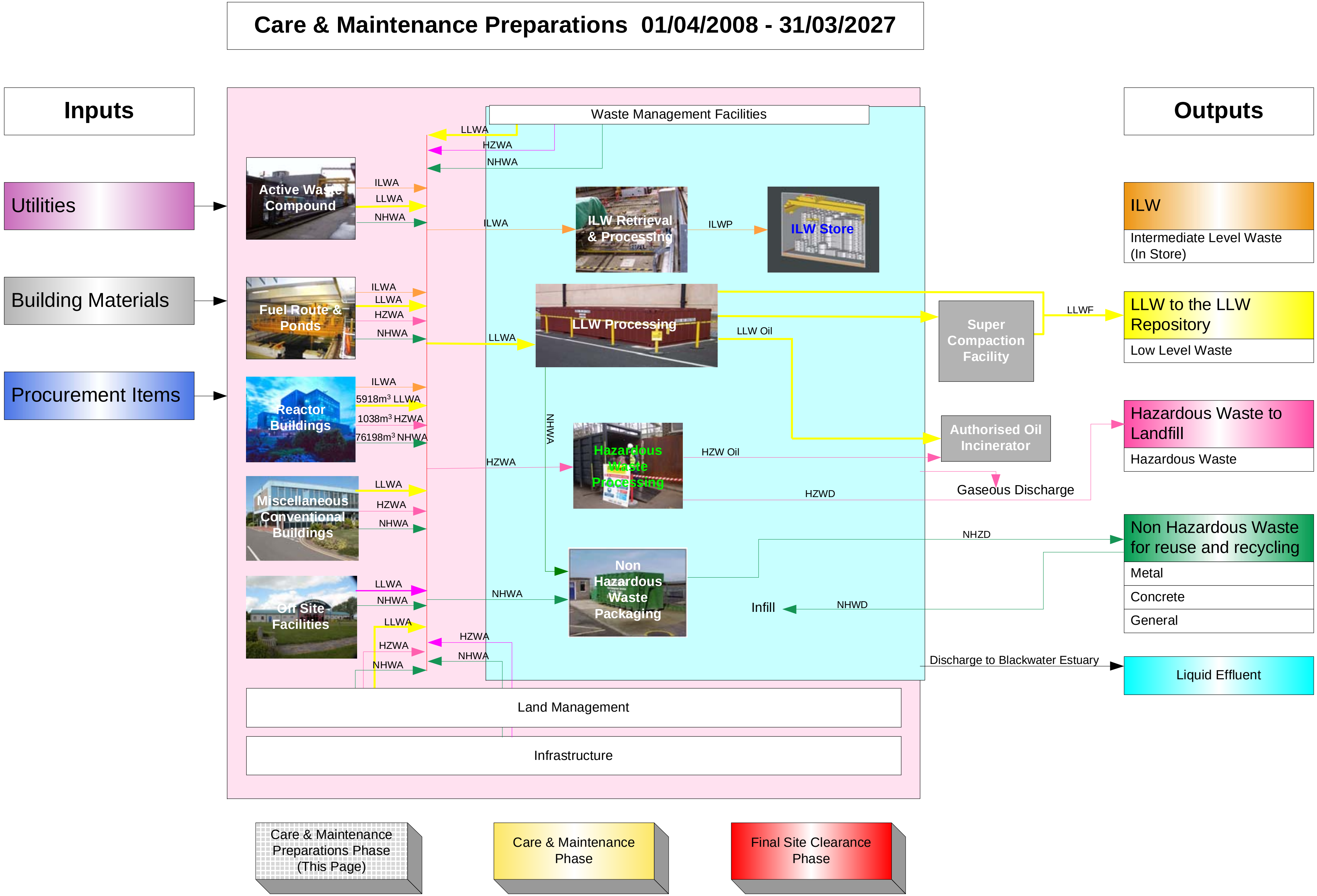
- Production and implementation of a management strategy for any contaminated ground.

- Safestore preparations. Preparing the site and the few minor buildings remaining at the end of the C&M Preps period, for the quiescent C&M period by ensuring the buildings are weatherproof and secure and installing appropriate monitoring and security systems.

- Re-wiring of Essential Equipment systems to the new Electrical and C&I Overlay systems. This will facilitate the 'islanding' of the main site buildings allowing decabling and subsequent decommissioning and demolition to be undertaken.

To support the work during the C&M Preps period it may be necessary to construct a number of new, mainly temporary, facilities either within existing buildings or as new buildings. These may be necessary for the retrieval, processing, packaging and storage of operational ILW, and for the management of the significant quantities of low level radioactive waste (LLW) that results from the dismantling and demolition work. Such new facilities, other than any ILW store and a small electrical overlay substation (to provide power to the site through C&M for monitoring and infrastructure purposes), will be removed at the end of the C&M Preps period.

An indication of the main activities and process flows during the C&M Preps phase is provided in Figure 1 below.


Care & Maintenance Preparations 01/04/2008 - 31/03/2027
Inputs
Utilities
Building Materials
Procurement Items
Waste Management Facilities
LLWA
HZWA
NHWA
Active Waste Compound
ILWA
LLWA
NHWA
ILWA
ILW Retrieval & Processing
ILWP
ILW Store
Fuel Route & Ponds
ILWA
LLWA
HZWA
NHWA
LLWA
LLW Processing
LLW Oil
Super Compaction Facility
LLWF
Reactor Buildings
ILWA
5918m³ LLWA
1038m³ HZWA
76198m³ NHWA
NHWA
Authorised Oil Incinerator
HZWA
Hazardous Waste Processing
HZW Oil
Gaseous Discharge
HZWD
Miscellaneous Conventional Buildings
LLWA
HZWA
NHWA
NHZD
Off Site Facilities
LLWA
NHWA
NHWA
Non Hazardous Waste Packaging
Infill
NHWD
LLWA
HZWA
NHWA
HZWA
NHWA
Discharge to Blackwater Estuary
Land Management
Infrastructure
Outputs
ILW
Intermediate Level Waste (In Store)
LLW to the LLW Repository
Low Level Waste
Hazardous Waste to Landfill
Hazardous Waste
Non Hazardous Waste for reuse and recycling
Metal
Concrete
General
Liquid Effluent
Care & Maintenance Preparations Phase (This Page)
Care & Maintenance Phase
Final Site Clearance Phase

1.2.2 C&M Phase:

Following the period of C&M Preps currently scheduled for completion by the end of March 2027, Bradwell will enter Care and Maintenance (C&M). This is a specified period where the site stays in a passively safe, quiescent state and during which no significant dismantling work occurs. This allows the radioactivity on site to decay, therefore allowing the radiological benefits to be accrued from the deferral of the final dismantling activities.

Throughout the C&M phase, manned sites, surveillance and security, radiological and environmental monitoring and programmed inspection and maintenance of the buildings remaining on site is provided for.

The C&M period at the site is currently planned to continue to 2095.

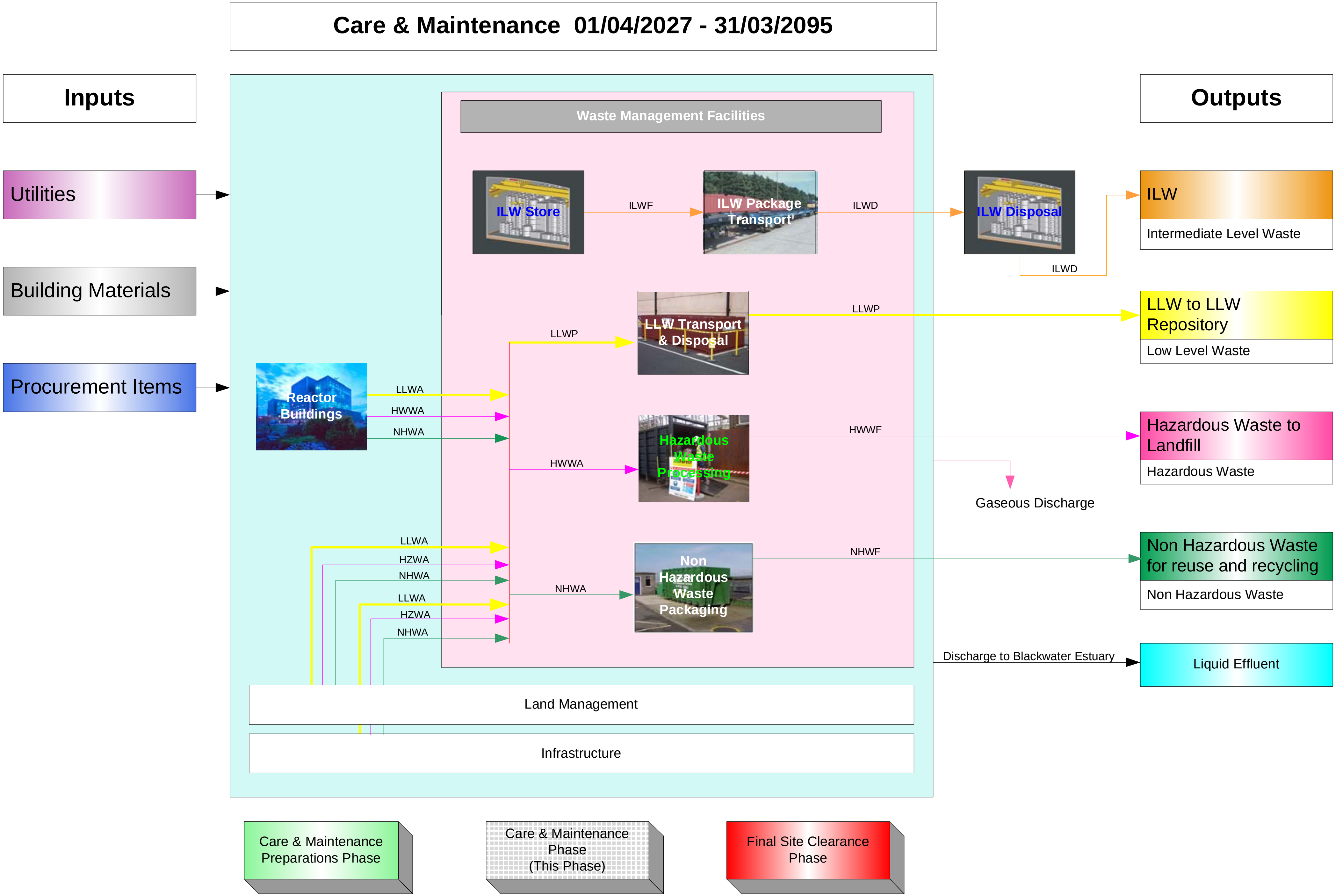
For planning purposes only, it is assumed that a deep waste repository for ILW will be available in 2040. However, the timing of actual waste disposal from any particular site will be some time after 2040. ILW disposal will be subject to a national prioritisation framework yet to be developed. The on-site ILW store, once emptied, will remain in-situ until the FSC phase when it will be cleaned, decommissioned and demolished.

The main activities undertaken during the C&M period will be to maintain appropriate monitoring, surveillance, inspection and maintenance of the site to ensure that it remains in a safe and secure condition. Funding is included in the LTP to provide for roof and cladding replacement after a 30-year period. However, as the site will be in a passively safe state, in accordance with the principles of passive safety, the need for maintenance, monitoring and other human intervention is minimised.

The plans for the C&M period at Bradwell Decommissioning Site have not yet been finalised, nor have the Regulators approved them, particularly in respect of the level of site occupancy. A cautious approach has therefore been taken and the need for a transitional period at the end of the C&M Preps phase. During this time, it will be necessary to demonstrate the continuing safety and security of the site prior to fully entering the C&M period when site occupancy can be reduced to a minimum level.

During the C&M period, the Bradwell site will remain a nuclear licensed site subject to nuclear licence conditions and independent regulatory scrutiny, to ensure that safety, environmental and security standards remain high.

An indication of the main activities and process flows during the C&M phase is provided in Figure 2 below.


Care & Maintenance 01/04/2027 - 31/03/2095
Inputs
Utilities
Building Materials
Procurement Items
Waste Management Facilities
ILW Store
ILWF
ILW Package Transport
ILWD
ILW Disposal
ILWD
LLWP
LLW Transport & Disposal
LLWP
Reactor Buildings
LLWA
HWWA
NHWA
HWWF
HWWA
Hazardous Waste Processing
LLWA
HZWA
NHWA
LLWA
HZWA
NHWA
NHWA
Non Hazardous Waste Packaging
NHWF
Land Management
Infrastructure
Outputs
ILW
Intermediate Level Waste
LLW to LLW Repository
Low Level Waste
Hazardous Waste to Landfill
Hazardous Waste
Gaseous Discharge
Non Hazardous Waste for reuse and recycling
Non Hazardous Waste
Discharge to Blackwater Estuary
Liquid Effluent
Care & Maintenance Preparations Phase
Care & Maintenance Phase (This Phase)
Final Site Clearance Phase

1.2.3 FSC Phase:

Following the C&M phase, scheduled for 2095 the site will begin full dismantling and remediation in the Final Site Clearance phase, which will result in the site being de-licensed and available for future use by 2104.

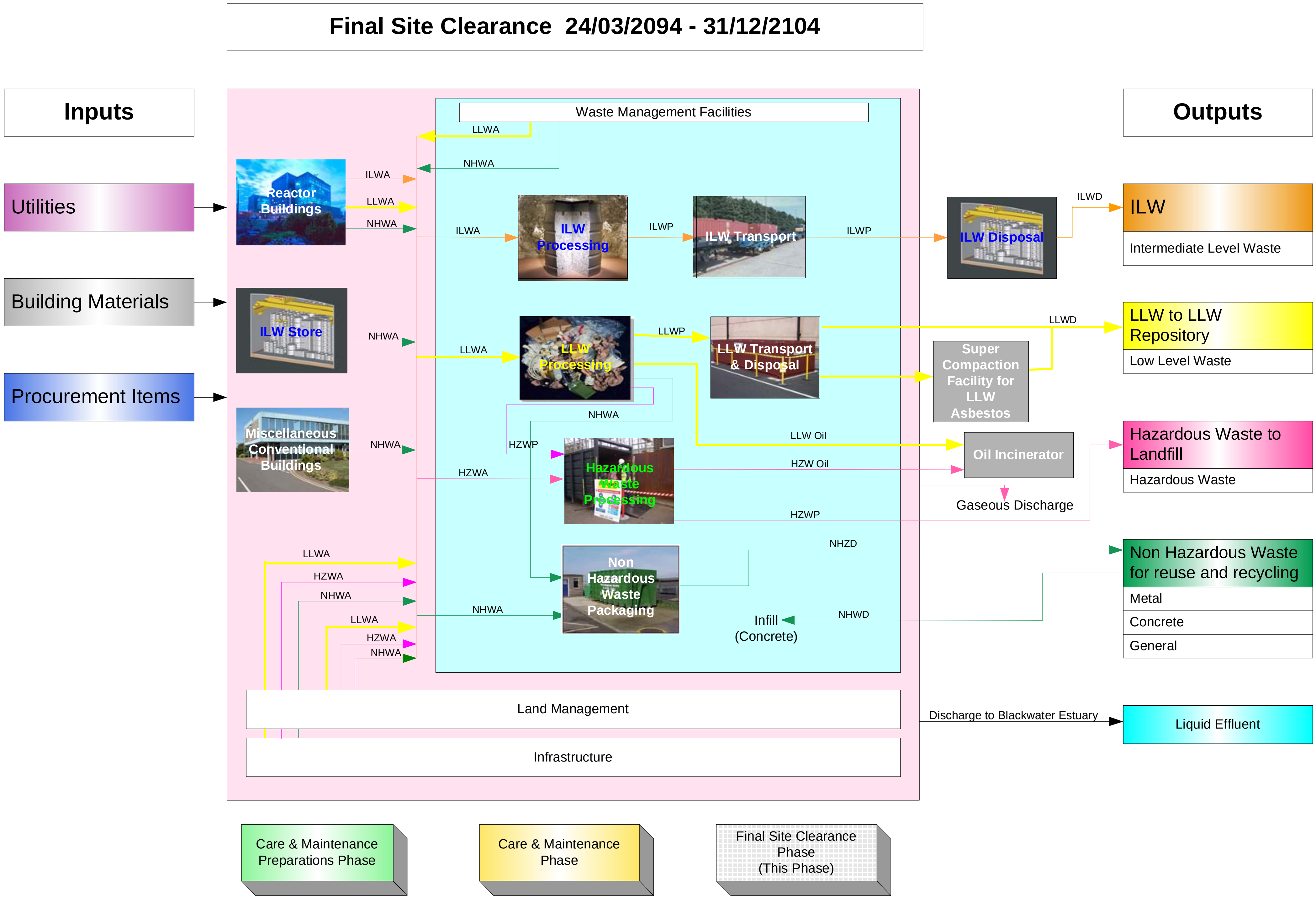
The exact site end point for the site is yet to be agreed, but for the purposes of this TBRD, it is assumed to be a fully de-licensed site with all structures removed to at least ground level, landscaped and planted with appropriate locally indigenous flora thus allowing the site to be made available for future use.

This includes the complete the removal of the remaining buildings on the site, i.e. the reactor bio-shield and reactor components, the remaining primary gas circuit components and the Miscellaneous Activated Components (MAC) stored in the quarter voids.

In order to progress this work it will be necessary to install new site infrastructure facilities, e.g. offices, workshops, waste treatment plants, etc.

The proposed technical baseline for Final Site Clearance is currently planned to commence in 2095 with completion in 2104, however as previously discussed, Bradwell is assessing options that would allow for acceleration of FSC activities.

An indication of the main activities and process flows during the FSC phase is provided in Figure 3 below.


Final Site Clearance 24/03/2094 - 31/12/2104
Inputs
Utilities
Building Materials
Procurement Items
Waste Management Facilities
LLWA
NHWA
Reactor Buildings
ILWA
LLWA
NHWA
ILW Store
NHWA
Miscellaneous Conventional Buildings
NHWA
ILWA
ILW Processing
ILWP
ILW Transport
ILWP
ILW Disposal
ILWD
LLWA
LLW Processing
LLWP
LLW Transport & Disposal
Super Compaction Facility for LLW Asbestos
LLWD
NHWA
HZWP
HZWA
Hazardous Waste Processing
LLW Oil
HZW Oil
Oil Incinerator
Gaseous Discharge
HZWP
NHZD
Non Hazardous Waste Packaging
NHWA
Infill (Concrete)
NHWD
LLWA
HZWA
NHWA
LLWA
HZWA
NHWA
Land Management
Infrastructure
Discharge to Blackwater Estuary
Outputs
ILW
Intermediate Level Waste
LLW to LLW Repository
Low Level Waste
Hazardous Waste to Landfill
Hazardous Waste
Non Hazardous Waste for reuse and recycling
Metal
Concrete
General
Liquid Effluent
Care & Maintenance Preparations Phase
Care & Maintenance Phase
Final Site Clearance Phase (This Phase)

1.3 General Assumptions

- Government policy and standards, together with the legislative and regulatory environment, remain unchanged, or changes pending have no significant impact.

- Strategies will be optimised against all relevant factors as required by Government Policy.

- Strategies reflect only currently available technologies.

- Sufficient Suitably Qualified & Experienced (SQEP) resource exists nationally to undertake the scope of work.

- Sufficient external licensed hazardous material and special waste disposal facilities will be available to receive all hazardous material requiring removal from the site.

- The National LLW Repository conditions for acceptance continue to apply unchanged; when this facility reaches the end of its working life, an alternative and equivalent site will be available.

- For planning purposes only, a deep waste repository for ILW will be available in 2040. However, the timing of actual waste disposal from any particular site will be some time after 2040. ILW disposal will be subject to a national prioritisation framework yet to be developed.

- There will be a reasonably practicable interpretation of the ‘no danger’ clause in the Nuclear Installations Act 1965 (as amended) so as to facilitate de-licensing.

The validity and implications of these assumptions are kept under ongoing review.

1.4 Key Site Assumptions

The key assumptions for Bradwell Decommissioning Site include:

New construction projects:

- The Solid & Wet (Mobile) Intermediate Level Waste (ILW) will be retrieved, processed and immobilised in stainless steel containers, to comply with ILW Waste Package specifications. Immobilised waste will subsequently be stored on site in an interim ILW Store until an off-site final deep geological repository is available. (Note: Mobile waste is defined as material that has a nominal cross sectional width of less than 5 mm). The choice of package for waste conditioning is a ILW Waste Package 3m^3 Boxes for encapsulating solid wastes and ILW Waste Package 3m^3 Drums for solidifying mobile waste with the exception of spent dryer desiccant which it is intended to be stored, in a non-grouted state, within rubber-lined appropriately approved 500 litre stainless steel drums, until a BPEO solution that satisfies all regulators can be derived. It is anticipated that this will be encapsulated in a cement based matrix to produce a waste compliant package.

- The current strategy is to combine the organic/inorganic Ion Exchange (IX) resins with the settled ILW sludges, utilising a developed formulation, to optimise the quantity of ILW Waste compliant packages produced.

- The Wet and Solid ILW immobilisation processes will be a combined in a single facility, to maximise the synergy cost reductions on common equipment.

- The Reactor Building Safestore, including the new pilecap roof, will require maintenance at 30-year intervals until Final Site Clearance. The 'Back to Bioshield' strategy assumes that no cladding is required for the bioshield.

Decommissioning & Termination:

- The reactor buildings, primary circuit (comprising ductwork within the reactor bioshield) and Miscellaneous Activated Components (MAC) will remain in situ until final site clearance. The MAC includes material currently stored in the quarter voids and pile cap storage holes, and control rods currently located within the reactor pressure vessel. Heat exchangers and primary circuit ductwork will be stored on-site pending investigations to establish the BPEO for the final disposal route.

- It is assumed that the potential scope of the Back to Bioshield project will require the Environmental Impact Assessment document (EIAD) to be reviewed.

Waste & Nuclear Materials Management:

- The National ILW Repository will be available from 2040, and will be able to accept Bradwell Site's packaged ILW between 2043 and 2045.

Strategy assumptions:

- The site will be placed into 'Care & Maintenance' phase with the reactor buildings and ILW store maintained in a quiescent state for 80 years to allow for natural radioactive decay. All ancillary buildings will be removed and the reactor building deplanted 'Back to Bioshield' including the heat exchangers, primary circuit ductwork external to the bioshield and all pile cap charge face equipment. All bioshield penetrations will be sealed and a roof structure will be constructed above the pile cap. Currently it is assumed that ongoing monitoring of the site during C&M will be carried out from a central, remote location with periodic, routine inspections and maintenance only being carried out on the site. Until a suitable safety case has been produced to support this assumption and satisfy the regulators, the current baseline in the Lifetime plan is that the site will be manned by a small number of security staff during the C&M phase.

- The end-state of the Bradwell will be a de-licensed site for future re-use. The exact end state will be agreed with the local stakeholders and implemented accordingly via change control (if necessary) into the Lifetime Plan.

The validity and implications of these assumptions are also kept under ongoing review.

1.5 Risk Management Overview

Bradwell site implements processes and policies with respect to Risk Management to ensure compliance with NDA procedure PCP10. They are intended to develop a risk awareness environment and culture on the site. This supports continual improvement, sharing of lessons learned and good practice throughout the delivery of the Bradwell decommissioning programme.

The Bradwell Risk Management processes incorporate the following elements:

- Identifying risks
- Assessing risks
- Managing risks
- Reviewing risks
- Reporting risks

Specifically the TBRD risk is managed through the following framework:

- Technical risks are identified with respect to the technical maturity of the approach, the uncertainties associated with the task and factors that could influence successful completion.
- Evaluate risk impact and probability of occurrence.
- Development of mitigation plans to minimise risk occurrence or impact and contingency plans should risk materialise during project execution.
- Project cost includes contingency funding relative to the risk associated with project execution.
- The risks associated with a technology and any associated R&D work are referenced and managed through the DV for the delivery for that work.

2 Technology Successes

To further demonstrate the importance of technology and technical support to the delivery of the Bradwell Lifetime Plan, this section details of some of the successes that have been achieved at the site over the last year that were supported wholly or significantly by technical input.

- Completion of a Best Practical Means (BPM) study for FED processing and disposal, that avoids the need for a cross site transporter. This process engaged the Regulators and Stakeholders (EA, Local Community Liaison Committee (LCLC) and Magnox South DSO) in the decision making process. This enabled decisions to be made that increased the Technology Readiness Level (TRL) of elements of the work.

- Retrieval and processing of ILW sludge within settling Tank 62V to produce 200 litre drums of LLW for disposal to the UK LLWR.

- Design of vibro-pile stone columns to improve the ground used for the construction of the LLW Management facility.

- Self performance of the Circulator hall Deplant task, using craftsmen who had worked on maintaining and overhauling the units previously. This enabled the equipment to be dismantled into suitably sized items which could be surveyed and decontaminated; enabling free release items to be segregated from the LLW. This significantly reduced the amount of equipment that was consigned to the National LLW Repository.

- Obtained consent from the Environment Agency (EA) to employ ‘activity averaging’ for consignments of non-contaminated asbestos and asbestos contaminated with low levels of Tritium. This reduced the consignments of contaminated waste that were sent to the National LLW Repository.

- The replacement of the ‘quilling’ process, utilising wet shot blasting to remove the remaining ingrained asbestos; with a ‘dry ice’ cleaning system. This removed the need to use absorbent material to soak up the water which was subsequently despatched as hazardous waste to landfill.

3 Good Practice

In the past year Bradwell has both initiated and adopted a number of good practices. These have been shared with other Magnox South Sites through project closeout procedures and peer group meetings. For Bradwell, this includes the following:

- Lessons Learnt workshop held to review the experiences from the Electrical and Control & Instrumentation overlay projects.

- Co-ordination with Sizewell A and DSO in development of FED dissolution opportunity and participation in BPEO/BPM studies. Use of Sizewell and Dungeness Letter of Compliance submissions for management of the interim storage of ILW components that will be retrieved with the FED waste.

- Co-ordination of design development of the FED waste retrieval facility with ongoing projects for BNLS AWVR project and Sellafield B30 and B41 projects. Lessons learnt from Hunterston experience in use of Brokk hydraulic arms incorporated in design.

- Further enhancement of the Project Risk Register to specifically identify and include Technical Risks and Issues, for ongoing management and action.

4 Technical Baseline Table

The Technical Baseline Table for Bradwell is presented in Tables 1 (work that is progressing in FY2008-09), 1A (work that is on-hold for 2008-09) and 1B (work that has been completed or deleted) in accordance with NDA guidance given in PCP07. The tables provide:

- A description of each major task associated with the current Baseline, with an overview of the proposed technique to be used in carrying out the work.

- Key technical assumptions explaining why the particular process has been chosen and where it has been used before.

- Technical constraints, such as infrastructure, that may limit the application of the technique.

- Areas where further work is required to underpin the proposed processes.

The tables also provide Bradwell's judgement of Technology Readiness Level (TRL) as a guide to maturity or readiness of the proposed technique or process. NDA has defined the TRL scale between 1 and 9 (see Appendix 1). Justifying a TRL of 9 requires that the technique or process be proven through successful operations and that reliability and maintainability have been demonstrated. If a TRL of 9 cannot be justified, the gap is identified as an R&D requirement.

This development work will then support improvement of the technology maturity categorisation and the subsequent reduction in risk. It will include, for example, pilot and full scale trials, e.g. trials to be conducted on ILW retrieved from the vaults.

This also supports continual improvement in Bradwell's technical performance with respect to identifying, developing, implementing and sharing good practice for innovations and opportunities to improve the current site baseline in terms of time and cost, safety and environmental impact.

The tables are divided into the areas of decommissioning work detailed in the LTP with the entry reference number matching the CWBS number of the detailed work package.

5 Research & Development (R&D) Table

The Bradwell R& D requirements in support of the Technical Baseline are presented in Tables 2 (work that is progressing in FY2008-09), 2A (work that is on-hold for 2008-09) and 2B (work that has been completed or deleted) in accordance with NDA guidance given in PCP07. The R&D requirements are described as:

- Activities needed to underpin the current Baseline (needs or risk management).
- Innovative R&D activities initiated by Bradwell in support of acceleration and/or further optimisation of the Baseline (opportunities).

The tables set out the technical need, explaining what has to be done and why, putting the technology gap into context. The Table provides the key outputs expected from the R&D proposals and sets out, at high level, how these outputs will be used. In addition, Table 2 presents the date when the solution should be in place to allow successful action on the Lifetime Plan (which must, of course, be after the expected R&D delivery date), together with the approximate cost of delivering the completed R&D bounded in four ranges:

<£50k
£50k - £100k
£100k - £1M
>£1M

5.1 Nuclear Research Schedule work

The Decommissioning Strategies Organisation (DSO) and the Reactor Waste and Decommissioning Technology Group (RWDTG) have a major role of oversight, development and management of Waste and Decommissioning Research and Development (W&D R&D).

The group provides strategic direction and oversight of Magnox Electric's generic W&D R&D programme by undertaking the following tasks:

- Directing a coordinated and cost effective R&D programme within "Reactor Sites" in support of radioactive waste management and decommissioning issues.

- Providing an inter-site forum for Magnox Electric Limited for the sharing of technology development work undertaken and led by individual sites.

- Directing the balance between longer term R&D and the needs for more immediate individual site demands.

- Providing a strategic input into R&D programmes.

- Overseeing the preparation and delivery of the Licensee's Nuclear Research Schedule (or its replacement) on an annual basis.

The specific generic work that supports Bradwell site's technical baseline and R&D programme; by developing the TRL, the mitigation of technical risks and development of opportunities, is referenced in the R&D table. More detailed information is contained in the R&D table of the Magnox Electric Limited Waste and Decommissioning Research & Development Programme document.

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Appendix 1 NDA Guidance from PCP-07

Technology Readiness Levels Table (TRL)

Basic Technology Research	Level 1	Basic principles observed and reported
Research to Prove Feasibility	Level 2	Technology concept and/or application Formulated
	Level 3	Analytical and experimental critical functions and/or characteristic proof of concept
Technology Development	Level 4	Component and/or bench validation in laboratory environment
Technology Demonstration	Level 5	Component and/or bench validation in relevant environment
	Level 6	System/subsystem model or prototype demonstration in relevant environment
System/Subsystem Development	Level 7	System prototype demonstration in an operational environment
System Test & Operation	Level 8	Actual system completed and qualified through test and demonstration
	Level 9	Actual system proven through successful operations e.g. through reliability and maintainability demonstration in service

Table 1: Bradwell Decommissioning Site - Technical Baseline: Work progressing in FY2008 – 2009

1.0 1.1.1. 22.11.12. 22035. 22136	**Opportunity for Dissolution** **(Solid ILW - Retrieval & Processing)**	**Overview:** During the operational lifetime of Bradwell Power Station, Intermediate Level Waste (ILW) arisings were placed in the Active Waste Vaults, loose and in packaging. Future arisings will occur during the deplanting and decontamination of the Cooling Pond complex and the Reactor charge face de-plant. The Solid ILW Project consists of the design, procurement, construction, operation, commissioning and ultimate decommissioning of the necessary plant/equipment to retrieve, process and ultimately encapsulate the above material. This is the current technical baseline strategy. The current scope of the Opportunity for Dissolution project deals with the retrieval and processing, by dissolution in Nitric Acid, of Fuel Element Debris (FED) consisting of mainly Magnox splitters and minor quantities of fuel fragments and activated components (Nimonic springs, end fittings and thermocouple assemblies). In addition to these materials, the retrieval and processing scope will include the contaminated gravel layer at the bottom of the vaults and the FED corrosion products which are assumed to be in the form of fine particulate and will be treated and processed as Wet ILW (sludge).						Refs: 21, 22,
Task / Process ID.	**Task/Process description**	**Preceding task**	**Technique**	**TRL**	**Assumptions**	**Technical constraints**	**Gaps (ref to R&D table)**	**Key reference documents**
1.1 1.1.1.22.1 1.12.2203 5.22136	Retrieval Equipment		The project has passed through the concept design phase and is currently progressing through the developed design feasibility stage. The current engineering basis is to deploy conventional equipment, potentially as used within the automotive and civil industry. Typically, this will consist of a telescopic, vertical mast mounted with a Brokk retrieval arm, fitted with suitable end effectors for retrieving the FED material and the gravel layer at the base of the vaults. The FED will be in the form of compacted splitters and varying particulate sizes of FED corrosion products. It is intended to mount the system on a gantry, located integrally within a shielded, contained, bunded structure that will travel above the Active Waste Vaults (AWV) on the existing crane rail system. The current AWV crane will be retained to remove the shield plugs from the vaults. The existing crane has a SWL of 5.5 tonnes. The retrieval unit will consist of shielding, containment, fire suppression and active ventilation systems. The connection between the retrieval module and the processing module will contain a shield door, located in the retrieval module. Containment will be maintained by a manually deployed flexible sealing arrangement.	6	The retrieval system will only be used to remove small masses of material (25 – 50 kg) with the existing vault crane removing any heavy items found in the vaults. The quantity of FED corrosion products will not exceed 12.5% of the total FED material. (22/22137/168 and 22/22134/262) The docking and sealing of the containment of the retrieval unit to the active waste vault will be a manual operation The unit will be a standard unit that will not require any major 'nuclear' adaptations, particularly from the activity from the nimonic springs. The existing Vault plug openings will be suitable for deploying the retrieval arm assembly without further modifications.	The operational speed and reliability of the unit will need to meet the throughput requirements. The existing AWV crane rail system foundations will be capable of taking the loading of the retrieval unit, including any shielding requirements, without any major modifications. The existing ventilation, fire detection, hydrogen detection and vault water removal systems in the dormant vaults containing FED will need to be maintained during the retrieval operation to satisfy the existing Radwaste safety case. A gamma probe will be deployed to ensure that each grab of FED material does not contain excessive quantities of activated components which would challenge the shielding arrangements.	Current development work at Hinkley, Berkeley, Trawsfynydd, Sellafield and developments from the central Magnox South decommissioning strategy organisation (DSO), will be continuously monitored to incorporate any significant design features, compatible with the Bradwell specific design. Following sampling studies, simulants specifications will be developed for future use in larger scale trials to evaluate the option selected. The concept of the telescopic mast and arm will need to be evaluated in trials with the potential manufacturers, to determine suitability and throughput rates. Liaison with on-going trials by Sellafield of similar equipment will be established to achieve cost effective R&D.	R&D 1 (08) MEL W&D R&D FED Retrieval

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
					The Retrieval unit will run on the existing AWV crane rails. The crane rails will be capable of accepting the imposed loadings (22/22134/268 and 22/22134/263) The shielding of the retrieval unit, located above the vaults, will be optimised based on retrieving only one or two nimonic springs at a time. The retrieval equipment will be operated remotely by the operators using CCTV monitors.		An assessment and evaluation trial of various docking and flexible connection systems will be required to satisfy the 'mobile' nature of the Retrieval module. Detailed, intrusive ground surveys may be required to substantiate the details of the vault and crane rail construction as detailed on site drawings, including soil conditions. (22034 – 9) (22034 – 10)	
1.2 1.1.1.22.1 1.12.2203 5.22136	Fire detection and suppression system		Until presentations by Magnox South to support the incredibility of FED fires being initiated by Uranium Hydride ignition, have been accepted by the regulators, the baseline is to install fire detection and suppression systems for the FED storage vaults within the AWV, for the retrieval operations. BPM studies will be conducted to select the optimum solution. The 'Oxy-Reduct' system is currently being developed for use at Hunterston and Argon suppression systems are already in use at Berkeley and Trawsfynydd. A combination of these systems will be evaluated.	6	It is assumed that a fire suppression system is required for the FED retrieval operations. (22/22134/274)	The system must be capable of integrating into the HEPA ventilation and Hydrogen removal requirements for the retrieval operations and maintain the operational requirements for the existing Radwaste safety case. The possible combination of Argon suppression and the Oxy-Reduct system must provide fire suppression for vaults with only top connections for the inlet and extraction points.	Further development work may be required to support safety case arguments to support the incredibility of Uranium Hydride initiated FED fires. Dependent on the lessons learnt from the deployment of an Oxy-Reduct system for the FED retrieval at Hunterston, further development work may be required to adapt and integrate the system for use at Bradwell.	R&D 2 (08)

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
1.3 1.1.1.22.1 1.12.2203 5.22136	Active Ventilation system		Active, HEPA filtered ventilation systems are required for the Retrieval and Dissolution modules. The systems will provide a suitable depression to maintain containment. In addition, the system linked to the retrieval module will be integrated with the Oxy-Reduct system to provide suitable fire suppression. The system linked to the Dissolution module will also be required to dilute the Hydrogen generated from the FED reaction with Nitric Acid to a nominal level of 1% vol/vol in air (i.e. 25% of the LEL for Hydrogen).	6 8	It is assumed that a fire suppression system is required for the FED retrieval operations and will need to be integrated into the active system. (22/22134/274) It is assumed that the ventilation system in the Dissolution module must maintain the Hydrogen concentration to less than 1% vol/vol. (22/22134/266 and 22/22137/169)	The total system must be capable of integrating the HEPA ventilation / fire suppression in the Retrieval module and Hydrogen removal requirements for the Dissolution module, while maintaining the operational requirements for the existing Radwaste safety case. The possible combination of Argon suppression and the Oxy-Reduct system must provide fire suppression for vaults with only top connections for the inlet and extraction points.	Further development work may be required to support safety case arguments to support the incredibility of Uranium Hydride initiated FED fires. Dependent on the lessons learnt from the deployment of an Oxy-Reduct system for the FED retrieval at Hunterston, further development work may be required to adapt and integrate the system for use at Bradwell. During design development, the location and connection of the ventilation systems to the Retrieval and Dissolution modules will be developed.	R&D 2 (08) R&D 4 (08)
1.4 1.1.1.22.1 1.12.2203 5.22136	Retrieval arm and robotic device end effectors.		Suitable petal grabs, pincers, grips, rakes and hose attachments will be utilised to undertake the range of operations that are required of these devices. It is intended to use existing systems with only minor modifications.	6	Standard end effector units can be utilised without needing to design them from first principles.	The items will need to be robust enough to remove FED and gravel, yet intricate enough to remove small fragments of fuel and Nimonic springs	Current development work at Hinkley, Berkeley, Trawsfynydd and Sellafield, will be continuously monitored to incorporate any significant design features, compatible with the Bradwell specific design. Following sampling studies, simulants specifications will be developed for future use in larger scale trials to evaluate the option(s) selected.	R&D 3 (08)
1.5 1.1.1.22.1 1.12.2203 5.22136	Pre-dissolution requirements		When the FED material is retrieved it is proposed to evaluate the requirements for further processing operations prior to the final dissolution process. This consists of the following: • Washing of the solid material to remove gross, loose contamination. This will only be required if there is	7	It is assumed that no significant pieces of fuel will be retrieved with the FED material. (22/22134/288)	If selected, any remote operated robotic device will be capable of visually identifying and picking up fragments of fuel and nimonic springs.	Development work at Hinkley, Berkeley and Trawsfynydd will be continuously monitored to incorporate any significant design features, compatible	R&D 1 (08) R&D 5 (08)

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
			an issue of the spread of contamination during the retrieval operation which is not considered ALARP. • Gamma inspection of the FED to identify significant fuel fragments, nimonic springs and other high activity items. These will be removed by a robotic device controlled by a remote operator prior to the transfer of the FED material to the Dissolution reaction vessels. The location of the facility to separate out high activity items has been evaluated in the BPM studies and will be integral with the retrieval/process facility. • Using the same robotic device, any build-up of items in the dissolution reaction vessels can be removed for processing as above into an interim ILW storage container.		The quantities of fuel fragments and activated items found can be placed into shielded containers for eventual encapsulation in a RWMD waste compliant container. The quantity of nimonic springs does not differ significantly from the upper estimate. (22/22137/170) Sufficient space will be available within the retrieval facility to locate the further processing options locally, if required. The Letter of Compliance submissions for interim storage of fuel fragments and activated items (Nimonic springs) by Sizewell and Dungeness can be used without major changes by Bradwell.	The gamma inspection system has suitable resolution within the operational environment to detect the high activity items. This will be capable of detecting items within large items of solid FED and FED sludges. The proposed facilities and devices will be capable of the throughput of the retrieval facility and the dissolution facility (i.e. will not create a bottle-neck). (22/22137/171)	with the Bradwell specific design. Following sampling studies, simulants specifications will be developed for use in potential equipment supplier demonstrations, to evaluate the option(s) selected, with respect to gamma inspection systems and robotic sorting devices. Further evaluation and size/layout development is required to assess the dose rates and confirm the suitability of the proposed location of the gamma inspection unit. Evaluation of suitable washing systems need to be undertaken for fines and adhered solid removal from the FED material. Evaluation of the RWMD requirements to ascertain if any additional supporting R&D is to be undertaken to substantiate the LoC submissions.	
1.6 1.1.1.22.1 1.12.2203 5.22136	Dissolution reaction vessel design and process control		• The quantity of FED to be placed in each reaction vessel is nominally 30kg. This will be a one-off 100 litre grab of material. The weight being added to the reaction vessel will be monitored by weigh cells on the sorting table. • The material will be placed in a basket and lowered into the reaction vessel. This will be used to retain any un-dissolved, non-FED items. • A Water and Nitric Acid dispensing system will control the quantity added to the reaction vessel, which will in turn control the rate of reaction and hydrogen generation.	5	It is assumed that the retrieval machine petal grab is capable of use by the operator to select and place a quantity of FED on the sorting table, weighing approximately 30kg. It is assumed systems can be obtained which can accurately monitor the weight of FED added to the reaction vessel and the liquid additions of water and Nitric Acid.	Integration of a weigh cell system into the sorting table design which will allow the sorting tray to move and the contents to be discharged to the reaction vessel. Optimisation of the acid dispensing system to ensure the reaction runs to completion without leaving a large acidic residue which may require neutralisation before pumping to the abatement system.	The output of the laboratory scale trials will need to be integrated into the full scale design of the reaction vessels. Further demonstration of design principles can be investigated using the pilot scale test rig.	R&D 3 (08) R&D 4 (08)

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
			• The agitation and mixing of the water and acid will be achieved by using an external pump to recycle the liquid contents of the vessel. • The above pump will also empty the contents of the vessel to the filtration / abatement system.		It is assumed that the design is suitably flexible that it is also capable of processing the FED corrosion products and the contaminated gravel. It is assumed a simple control system can be engineered to control the FED dissolution reaction rate to 'smooth' the generation of Hydrogen from the reaction. This will enable an optimised design to be produced for the ventilation system	Accurate real-time measurement of the Hydrogen evolution rate to ensure the reaction is smoothed and the level of Hydrogen does not exceed 1% vol/vol in air		
1.7 1.1.1.22.1 1.12.2203 5.22136	Fine filtration and activity abatement system.		• When the FED material has fully dissolved in the reaction vessel, the contents are pumped to the integral fine filtration and abatement system. • The fine particulate (less than 5-10 micron) is removed by fine filtration. • The majority of the soluble activity is removed by an Ion Exchange resin. • The final filtrate is discharged to the site Active Effluent Treatment Plant and onward to the Final Monitoring Tanks.	4	The fine filtration and abatement system will demonstrate BPM for this process. The resin selected will be tolerant of pH fluctuations, and will require only minor pre-treatment, if any, of the reaction vessel discharge. A suitable system for retrieval and interim packaging and storage of the ILW arisings will be designed and engineered. If required, existing interim storage facilities for any ILW arisings, will have sufficient capacity.	The system must be compact and tolerant of the chemicals and pH of the reaction system. The system selected must provide abatement levels to ensure that RSA compliance is achieved. The system must be designed to enable spent 'cartridges' to be remove and processed to produce packages that are, or can be processed to produce a RWMD compliant wasteform. The size of the equipment must fit into the dissolution module.	Laboratory scale trials are required using active samples of FED obtained from the ILW Characterisation project. Trials on suitable material and systems require to be undertaken to assist in BPM studies and final selection. When the output of the process has been determined then further modelling of the overall site discharges can be undertaken.	R&D 6 (08)

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
2.0 1.1.1. 22.13.32. 22035. 22114	**Ponds Complex Decontamination and Deplant**	**Overview:** The current scope of the Ponds decommissioning project for this year is to complete the draining of the pond, which includes the under water jet cleaning of gross surface contamination, and sealing of the remaining surface contamination while draining the Ponds water. A design review and upgrade of the existing Ponds Active ventilation system will be conducted to support the draining operations. A concept design of the scabbling operation and waste removal and disposal will be undertaken following the review of the Trawsfynydd process. In the following year, a contract will be placed for the developed and detailed design, equipment supply and installation. The scope of the Ponds Decommissioning Project is to remove all of the fixtures and contaminated material from the Pond Buildings, to prepare the buildings for demolition followed by demolition of the structures. This includes the Ponds building, Ponds Water Treatment Plant (PWTP) and Active Effluent Treatment Plant (AETP), including associated settling tanks, pipework and pumps. The baseline strategy for this work is based upon the full decontamination, decommissioning and demolition work of the ponds at Berkeley Power Station. Details of the radiological decontamination and decommissioning techniques are referenced, as well as a possible decontamination and demolition strategy study conducted at Sizewell. In addition, current activities at Trawsfynydd, including the mechanical scabbling operations and LLW packing and disposal systems will be reviewed for inclusion in the strategy and techniques for use at Bradwell. All tasks associated with Ponds Decommissioning will be readily achievable using commercially available and proven technologies and methods, identified through appropriate BPM studies. ALARP will be applied to all radiation hazard tasks and may result in minor modifications to existing technologies to enhance worker protection. The demolition of the ponds and similar structures is expected to be undertaken under specialist contract.						31, 32, 36
Task / Process ID.	**Task/Process description**	**Preceding task**	**Technique**	**TRL**	**Assumptions**	**Technical constraints**	**Gaps (ref to R&D table)**	**Key reference documents**
2.1 1.1.1.22.1 3.32.2203 5.22114	Active Ventilation System	Skip removal complete	A suitably rated and 'fit for purpose' active ventilation system will be designed and installed to enable the Ponds area to be maintained at C2 levels for the bulk of the ponds draining work. This will be reviewed and modified for the proposed scabbling operation. Local C3 facilities will be used for decontamination and size reduction activities.	8	It is currently assumed that this facility will be a 'fixed' fit for purpose system that will meet EA discharge regulations. It is assumed that it will be achieved by modifying the existing system and supplementing it with mobile units. It is not assumed that a complete, new system will be required. It is assumed that no new discharge routes will require authorisation by the EA and subsequent discharges will not breach the present RSA.	The ventilation system must create conditions which will produce ALARP working practises. The system will be capable of operating / supporting local C3 ventilated containment facilities for deplanting and decontamination activities. (22/22114/10)	Further development and design work is required to establish if temporary ventilation units can achieve the levels of containment and the working conditions required and satisfy regulatory requirements. (22114 – 15)	R&D 7 (08)
2.2 1.1.1.22.1 3.32.2203 5.22114	Removal of surface gross contamination and removal of remaining sludge.	Skip removal complete	A water jet cleaning system, deployed under the Ponds water surface, will be used to remove gross contamination and activity on the ponds wall surfaces. The main area will be the 'scum' line at the water interface. A methodology is to be developed to remove the remaining sludge within the Ponds. This will typically be a suction device and/or modifications in the ponds chemistry to dissolve the Magnox sludge.	7	It is assumed that the majority of the contamination and activity is on or close to the surface of the Ponds wall and can be removed by medium pressure washing techniques.	The water jet system deployed will be able to undertake the cleaning operations without creating a C3 contamination zone within the Ponds building.	Further development work and trials are required to identify suitable proprietary cleaning systems to be deployed. The development will mainly consist of field trials in the Ponds. The potential quantities of sludges produced will need to be estimated to ensure sufficient storage capacity is available.	R&D 8 (08)

Task / Process ID.	**Task/Process description**	**Preceding task**	**Technique**	**TRL**	**Assumptions**	**Technical constraints**	**Gaps (ref to R&D table)**	**Key reference documents**
					It is assumed that the material removed can be processed as ILW and can be retrieved and processed by the Ponds Water Treatment Plant. It is assumed that the total ILW material will not exceed 1m^3 and sufficient storage is available in the existing site sludge settling tank.	The ILW waste arisings from the cleaning process must be retrieved and processed by the PWTP, with the resulting backwash sludge being compatible for storage in the settling tank and the liquid discharges being compatible with the site discharge facilities to the Blackwater Estuary.	Further development work and trials are required to identify effects of changing Ponds chemistry on dissolution of the remaining sludge and the potential leaching of soluble activity within the Ponds structure. This will need to be evaluated against the usage and on-site storage of Ion Exchange resins.	
2.3 1.1.1.22.1 3.32.2203 5.22114	Drain Pond and transfer tunnels and apply surface sealant.	Active ventilation systems completed	The pond walls are to be decontaminated as far as practical, before draining the Cooling Pond, to minimise the radiological hazard. The Ponds chemistry will be modified to transfer soluble activity from the surface of underwater concrete structures into the aqueous phase, for removal in the PWTP Ion Exchange resin units. Simultaneously with the draining of the Ponds Water, a fixative/sealant will be applied to the surfaces to contain the remaining contamination.	6	The technique of a simultaneous operation of draining and sealing originally developed in the USA, can be used for this project. Further development work at Latina (Italy) supports this assumption. It is assumed that this can be undertaken manually and does not require, complex, remote equipment. The combination of sealant and surface activity removal will provide a suitable working environment to enable ALARP manual operations to be undertaken to complete the Ponds Deplant.	Use of ultra-high pressure water jet equipment underwater to minimise radiation hazards and airborne contamination prior to draining, will remove sufficient contamination and reduce the dose levels to R3/C2. The sealant used must be able to be processed as LLW during the Ponds scabbling phase.	Further peer review visits and development work will be undertaken to evaluate the application of the sealant as the Ponds water is being removed.	R&D 9 (08)
2.4 1.1.1.22.1 3.32.2203 5.22114	Remove fixed Pond Furniture	Clean and Drain Pond	The existing methodologies already developed within the project for handling skips and other LLW will be reviewed and enhanced to accommodate any differences from these that are associated with fixed Pond Furniture. Cold cutting techniques will be used to size reduce the plant items, typically hydraulic shears, saws and milling units. After size reduction, areas of contamination will be remove using abrasive blasting techniques, and possibly chemical cleaning, if appropriate.	8	Pond furniture will be decontaminated using standard decontamination methods to dispose of them to the National LLW repository. Significant size reduction will not be required to decontaminate the equipment to LLW.	Decontamination via conventional methods will be with due consideration of ALARP, environmental impact, safety, cost and schedule as appropriate.	Review of current ‘best practise’ and development trials will be undertaken to identify the most suitable methods for decontamination and size reduction of recovered items.	R&D 10 (08)

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
			Wherever possible, ALARP and BPM, the waste will be processed for release as LLW or free release.			The material recovered will be free release or LLW which will be suitable for treatment by metal melting process. (22/22144/186)	Metal waste may be disposed off via metal melting processes for recycling. Development of disposal techniques and routes currently being undertaken by Magnox South and Hinkley will be monitored for further development and use at Bradwell. This will be part of the Skip disposition programme.	
2.5 1.1.1.22.1 3.32.2203 5.22114	Decontaminate Cooling Ponds Structure and transfer tunnels, Concept Design phase only.	Remove fixed Pond Furniture	The depth of contamination into the concrete will be characterised (bore hole drilling for core samples) prior to removal of the contamination using mechanical scabbling methods as demonstrated at Berkeley and Trawsfynydd Power Stations (22/22114/13). This will comprise using a remote operated Brokk machine fitted with a scabbling head. (22/22114/06) The LLW arisings will be retrieved and package for disposal to the National LLW Repository.	8	The contamination from the ponds will be removed as LLW and will not exceed 125m^3 in volume. (22/22114/15 and 22/22114/12) The depth of the contamination will not exceed 40mm and the scabbling depth will not exceed 50mm. (22/22114/08) The concrete structure will not have steel re-enforcement material within the first 50mm of the structure. (22/22114/16) The sealant application and the modified ventilation system will provide working conditions that provide suitable containment classifications for the area. (22/22114/18)	The deployment and geometry of the scabbling equipment and waste handling facilities will need to be reviewed for the layout of the Ponds at Bradwell. Techniques are still to be developed for removing contamination in joints and seams in the concrete structure.	Demonstrate removal using scabbling methods. Review further developments and operational lessons learnt at Trawsfynydd for suitability for deployment at Bradwell. Review further developments in alternative methods such as hydrolasing. Undertake core sample survey to confirm assumptions on depth of contamination and rebar location. (22114 – 7, 8, 9 & 10)	R&D 11 (08) R&D 12 (08)

3.0 1.1.1. 22.13.36. 22035. 22145 & 22161	**Contaminated Land Survey and Remediation**	**Overview:** The nature and extent of radioactively and other (such as Hydrocarbons, asbestos etc.) contaminated ground (and/or groundwater) varies greatly from site to site (and within sites). Bradwell will continue to generate sufficient characterisation data for known and possible areas of contaminated ground on the site. This will enable the arrangements for long-term monitoring and the development of a strategy to manage the contaminated land to be determined in response to the requirements of EGG01. This will aid the selection of the preferred option(s) to ensure passive safety during Care and Maintenance and takes account of the intention to de-license the site at the end of Final Site Clearance.						
Task / Process ID.	**Task/Process description**	**Preceding task**	**Technique**	**TRL**	**Assumptions**	**Technical constraints**	**Gaps (ref to R&D table)**	**Key reference documents**
3.1 1.1.1.22.13.36.22035.22145 and 22161	Borehole sampling and characterisation The scope of work contains some further borehole sampling of the site, mainly within the RCA area.		Non-radioactive (chemical) and Radioactive ground contamination characterisation work is essential. This has previously included a desk-based review of historical information on historic spills/leaks; contaminated ground management, monitoring and site hydrogeological mapping followed by intrusive and non-intrusive characterisation intrusive methods (e.g. surface radiological surveys, borehole investigations). Further borehole sampling will be undertaken within the RCA to provide a more complete picture of any contamination. This will be followed by a routine of 6 monthly sampling to monitor the contamination in the long-term.	9	Currently, it is assumed that the main sources of contamination will be from damaged underground active effluent drain lines and the quantity of excavated material will not exceed 2530m^3. (22/22216/143)	Contamination may have occurred due to leakages from existing station facilities, e.g. Ponds, AWV. Direct borehole investigation of these areas will not be possible until a period near the end of C&M Preps when the structures have been decontaminated and demolished to below ground level.	Adequate characterisation techniques are essential to ensure the correct amount of remediation is performed. Development of a strategy to demonstrate to the Regulators that any radiological contamination remaining under the main structures is acceptable and can be managed in-situ.	See ref. 38 & 42. On-going surveys and samples will be taken, as required, to enable suspected contamination to be identified and produce a contaminated Land Strategy.
3.2 1.1.1.22.13.36.22035.22145 and 22161	Remediation	Sampling and characterisation	Any contamination found is managed in accordance with the relevant regulatory regimes mostly administered by the Environment Agency. Non-radioactive contamination is not directly relevant to eventual de-licensing of sites, but may influence future land use. The main strategy options include: • Removal of contamination (e.g. by excavation); • Enhanced containment *in situ*; • Monitoring the contamination *in situ* without engineered enhancement of containment. The main disposal route for LLW is to the National LLW Repository.	6	The Company has a contaminated land Intelligent Customer capability that will be consulted on the application of guidance information on contaminated land and the engagement of external contractors to manage this contamination. It is assumed that the current identified quantity of 3730m^3 of processed contaminated material will be consigned to the National LLW repository, which will still be available to accept waste with the current Conditions for Acceptance (CFA). (22/22144/158 and 22/22144/159).	Excavation and removal requires consideration of the options for treatment, storage and disposal of the resulting waste (typically very low activity LLW dominated by Cs_{137}). Existing underground Active drains will need to be immobilised into a passive state.	Retention of residual contamination in the ground requires a safety case for the duration of C&M. Techniques for sealing / and or remediation of underground active drains will need to be developed and progressed. Strategies will need to be developed to address the possible remediation techniques required. The opportunities for on-site disposal of very LLW, or cost-effective remediation/treatment will be considered. Developments being led by Hinkley and Magnox South DSO will be monitored for application at Bradwell.	Dependant on the extent and type of contamination found, the strategy and appropriate safety case will be developed. R&D for remediation techniques are not in the LTP08 scope.

Table 1A: Bradwell Decommissioning Site - Technical Baseline: Work on hold during FY2008 – 2009

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
1.0	**Wet ILW - Retrieval & Processing**	**Overview:** The Wet (Mobile) ILW projects (encompassed in several detailed volumes) involves the design, procurement, construction, in-active and active commissioning, operation and ultimately the decommissioning and demolition of plant and equipment to retrieve mobile waste forms from their current storage locations and immobilise within Nirex compliant packages to be transported to the on-site interim ILW store. The wet ILW waste forms, including future arisings will comprise: Fuel element corrosion sludge in Settling Tanks (ST) and also within the underground concrete FED storage vaults (dependant on the use of dissolution for the disposition of solid FED); AETP backwash sludge in one ST including future arisings from the Cooling Ponds clean-up and pond skip cleaning and decontamination; Ion exchange (IX) resin in one ST and in current operational units; Desiccant contained in the primary gas circuit driers and a small amount in drums contained in an underground concrete vault. It is assumed that the sand pressure filter medium and cation/anion water treatment resins will be treated as LLW and the graphite core dust (from the drier cyclone filter unit) will not be treated in the Wet ILW stream.						Refs: 13, 14, 15, 16, 17, 28, 29, 30, 37
1.1	Retrieval Process & Equipment		A conventional sludge handling system will be used to mobilise the waste and retrieve the sludge and IX resins from the current settling tanks located in the Active Waste Vaults (AWV). This will be based on in-tank agitator/mixers and positive displacement transfer systems. Various full-scale trials have been conducted using simulant materials to prove the technology's compatibility with the wastes currently at HPA. This will be reviewed and evaluated during the concept/feasibility design phase of the project. Current sludge retrieval work (Vault 6B) is being monitored for 'lessons learnt' using in-tank agitators and positive displacement pumping systems. Following sampling activities, information will be available to specify simulants for further large scale trials under a design concept review and any further R&D work that is identified as required will be prepared as a proposal to the NDA for consideration and approval.	6	The results of previous sampling activities have indicated that the properties of the various sludges, IX resins and other mobile materials, is similar to the waste arisings in other Magnox stations. Further planned, sampling activities will provide sufficient, representative information of the above materials to enable suitable simulants to be specified for larger scale trials. Retrieved material to be transferred in pressurised pipe work systems, not bowsers or similar. The Wet ILW processing facility will be remote to the retrieval operations located in the AWC	Previous experience from the sampling activity undertaken on the contents of tank 62V (Vault 6B) shows that the presence of rogue items is difficult to detect. The optimum location of the processing facilities with respect to the retrieval location, and the solids concentration of the sludges to be transferred; may preclude the use of low-pressure transfer systems. The IX resin settling/storage vessel is a pressure vessel with no significant sized openings. This would make the deployment of in-vessel mixing and pumping equipment problematical. Previous sampling studies have shown that the activity in the IX resin storage tank varies significantly (order of magnitude) in distinct layers. The contents need to be blended or a conservative 'worst case' activity needs to be used for the design basis.	Current development work at Hinkley, Berkeley and Hunterston will be continuously monitored to incorporate any significant design features, compatible with the Bradwell specific design. Simulants will be developed for use in larger scale trials to evaluate the option(s) selected. Technical reviews and trials will be required to evaluate the potential to modify the IX resin settling tank for in-tank deployment of equipment.	R&D A

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
1.2	Conveyance & Transportation System		The retrieval equipment is combined with a pressurised system used to convey the waste to another location for subsequent immobilisation. The pressurised system is used in conjunction with standard stainless steel pipework, potentially double contained and designed for handling slurries. Again, this equipment has been subject to full-scale trial to prove the technology's compatibility with the wastes currently at HPA. This is currently being reviewed and evaluated during the current concept/feasibility design phase of the project. Information gained from the pumping/re-circulation of the sludges from tank 62V will be reviewed for any further R&D work that is identified as required, and will be prepared as a proposal to the NDA for consideration and approval.	7	The distance to transfer the slurries, the viscosity of the slurry, the velocities required to prevent settling; do not preclude the use of pressurised piping transfer systems. Potential shielding requirements do not preclude the use of above ground piping transfer systems.	Suitable high-pressure pumping systems are available which do not result in high levels of material attrition, especially with the IX resins.	Current development work at Hinkley, Berkeley and Hunterston will be continuously monitored to incorporate any significant design features, compatible with the Bradwell specific design. Simulants will be developed for use in larger scale trials to evaluate the option(s) selected. Studies will be undertaken on the potential design solutions to evaluate the potential dose rates and shielding requirements and the potential deployment of these requirements (especially for pipe bridges).	R&D B R&D C R&D E
1.3	In-situ activity blending of the IX resins in Tank 56V		This will be achieved by the deployment of conventional agitator/mixer systems in conjunction with the pumping system re-circulating the contents of the vessel. The requirement to achieve a reasonably homogeneous mix (based on activity) is due to the stratification of activity within the vessel. Activities can vary by an order of magnitude. This is currently being reviewed and evaluated during the current concept/feasibility design phase of the project. Any design/technical issues identified, as requiring clarification and substantiation will be reviewed for any further R&D work that is identified as required, and will be prepared as a proposal to the NDA for consideration and approval.	5	It is assumed that it is feasible to blend the IX resins without causing excessive material attrition during the process, which creates further processing issues.	The IX resin settling/storage vessel is a pressure vessel with no significant sized openings. This would make the deployment of in-vessel equipment problematical. Sufficient samples of the IX resins are still available and in sufficient quantities to undertake evaluation trials.	Technical reviews and trials will be required to evaluate the potential to modify the IX resin settling tank for in-tank deployment of equipment. Although trials have been undertaken to prove retrieval and transfer systems, these trials would need to be modified or extended to gain information on potential mixing option(s) and their applicability.	R&D D
1.4	Dewatering and conditioning of waste streams		To ensure that the solids loadings of the sludges and the IX resins within the solidified wasteform are optimised, the waste streams will be conditioned by the Transportable Radioactive Sludge Dewatering Unit (TRSDU) that has been developed and trialed by BNG Project Services and is being installed for use at Trawsfynydd.	7	It is assumed that trials conducted on the pilot scale TRSDU and the subsequent operational results, especially for IX resins fines, will be repeatable on the full scale unit.	The requirement for a TRSDU system, or similar, will be necessary to ensure that highly active IX resin fines are removed and processed.	Substantiation trials on the pilot size TRSDU; using suitable simulants, will be required. It is anticipated that the TRSDU will also be involved in controlling the off-site discharge; therefore	R&D E

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
			This unit will also be used to condition slow settling or non-settling waste streams, particularly Magnox FED sludges and IX resins which have undergone attrition and particulate size reduction.		It is assumed that the current delivery lead times for supply of the unit will satisfy the site Lifetime Plan schedule requirements. It is assumed that the installation and operation of the TRSDU at Trawsfynydd will be successful and not require major modifications.	This will ensure that the site discharge is compliant, as the current site effluent systems could not remove these fines.	trials using dilute POCO waste streams will also be required. Development work will be required to substantiate the operational and cost benefits of using the TRSDU equipment for the volumes of waste arisings at Bradwell.	
1.5	Solidification of sludges and IX resins		Co-packaging and blending of sludges and IX resins to maximise waste loading and mixing with pre-blended cement powders to form a cementitious grout in $3m^3$ Nirex drums. This is based on the assumption that blends of organic/inorganic IX resins cannot be separated / differentiated; therefore the entire contents must be considered as organic for the worst case scenario, to satisfy the Nirex Letter of Compliance (LoC) submission. The de-watered sludge will be pumped to the Nirex drum and batched using the drum level measurement system, with the IX resin being batched in a separate vessel, prior to discharge to the Nirex drum. The blending will be achieved in the Nirex drum using the lost-paddle mixing device. The blended wastes shall be mixed with pre-blended cement powders and immobilised using the Waste Addition and Mixing Head (WAMH) system which forms part of the design of the Transportable ILW Solidification Plant (TILWSP). When cured, a capping grout is applied to seal the surface, trapping any fines that are present. The TILWSP unit has been proven at Trawsfynydd and is still currently in use. The WAMH facility will be located in a cell within the combined Solid and Wet Solidification facility.	6	Sludge can be accurately, volumetrically measured into a Nirex drum located within the Waste Addition and Mixing Head (WAMH) facility located in the combined Solid and Wet solidification plant. An accurate batching system can be designed to ensure the volume of IX resin added to the package can be achieved to satisfy the requirements of the Nirex LoC submission. It is assumed that Nirex will not place a lower restriction on the quantity of IX resin that can be blended with the sludges, for operational safety reasons. The Nirex drum lost-paddle device can achieve and maintain a homogeneous mixture of the sludge and IX resin during the all the mixing phases.	There is a finite limit to the volume of organic IX resin (approximately 360 litres) that can be packaged within a Nirex 3m3 drum without adversely affecting the integrity of the wasteform, cement monolith. The batching and mixing must be accurate and repeatable to ensure the chance of producing a non-compliant package is negligible. The throughput capacity of the WAMH/TRSDU combination of plant will provide the required throughput for the blended sludge/IX resin packages.	Development is required to produce a batching system for the IX resins that is compatible with the retrieval transfer system and the WAMH equipment. The system would then need to be demonstrated using simulants comprising blends of organic and inorganic resins. Previous trials for producing Nirex compliant wasteforms would need to be repeated with the specific properties of the Bradwell waste streams to develop a compliant formulation envelope, utilising the mixing system within the Nirex drum.	R&D D R&D E

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
1.6	Managing Waste Water Arisings		The transfer of sludge and IX resin arisings to the settling tanks and subsequently to the Wet ILW processing facility will typically generate excess supernate water. This will be re-used within the process, wherever possible, or passed through the TRSDU and then the site Active Effluent Treatment Plant (AETP) for activity abatement, prior to discharge off-site. During the later phases of operation, it is anticipated that the existing site AETP will be replaced with a mobile unit and buffer tank, rated for the required throughput and abatement performance.	7	It is assumed that the combination of the TRSDU and site AETP will provide sufficient processing and abatement of the wastewater arisings to comply with the Radioactive Substances Act (RSA) discharge consents for the site.	The combination of equipment will be capable of handling sub micron particulate (especially IX resin) and achieve satisfactory abatement levels to meet Environment Agency (EA) discharge consents.	The specific requirements of the Mobile AETP need to be determined to suit Bradwell site requirements. Suitable simulants will need to be specified to trial the combination of the pilot size TRSDU and the Mobile AETP for abatement performance and throughput data.	R&D S R&D E
1.7	Package Despatch & Cross Site Transport		Nirex compliant Solid and Wet ILW packages will be moved on site using a fit for purpose Cross Site Transporter unit. It is anticipated that a commercially available vehicle with minor modifications will be used for this purpose. This will carry the waste package in a shielded overpack system. All handling facilities will be designed with a suitable docking system to transfer the package from or to the overpack. The system will be replicated for the Solid ILW management facility and the ILW Store import/export/inspection facility.	6	The transporter system will be based on a proprietary unit with minor site-specific requirements changes. The design will be based on the loading standards for the existing site road system. The overpack system will satisfy Ionisation Radiation Regulations (IRR) for the site personnel and the public. The design and specification of the unit will be provided by the Solid and Wet ILW Retrieval Project.	Docking, loading and un-loading of the waste package must meet IRR requirements and may therefore need to be remote operations. The design will be constrain by the accuracy requirements for the docking arrangements within the ILW Store facility. The handling facilities associated with the Nirex Package will need to be compliant with the Approved Code of Practise.	Technical development of a 'docking' system needs to be progressed and could be centrally undertaken and co-ordinated.	R&D F
1.8	Facilities Housing		The equipment for the Wet ILW retrieval will be located within the AWV compound, within a simple, lightweight containment structure. Any shielding will be of a temporary, mobile design located on the vault structure. The Wet ILW processing facility will be located within the combined Solid and Wet ILW Solidification facility. This will share common operating processing such as container infeed and handling, waste container transfer, cleaning, swabbing and inspection facilities and final package handling to the Cross Site Transporter unit.	8	Typical concept designs of the process and initial shielding calculations have indicated that more substantial reinforced concrete shield walls are not required.	The load bearing abilities of the AWV structure may constrain the quantity and arrangement of shielding that may be deployed for the Wet ILW Retrieval operations.	Further development work on the Nirex package formulations and IX resin loadings will be required to develop the Nirex LoC submission. This will provide data for the more detailed shielding calculations when the general layout has also been developed.	R&D G R&D D

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
2.0	**Solid ILW - Retrieval & Processing**	**Overview:** (Awaiting the outcome for the Opportunity for Dissolution Project) During the operational lifetime of Bradwell Power Station, Intermediate Level Waste (ILW) arisings were placed in the Active Waste Vaults, loose and in packaging. Future arisings will occur during the deplanting and decontamination of the Cooling Pond complex and the Reactor charge face de-plant. The Solid ILW Project consists of the design, procurement, construction, operation, commissioning and ultimate decommissioning of the necessary plant/equipment to retrieve, process and ultimately encapsulate the above material. The current scope of the Solid ILW project deals with the retrieval and processing, by dissolution, of Fuel Element Debris (FED) consisting of mainly Magnox splitters, Miscellaneous Contaminated Items (MCI) and other materials, for immobilisation and storage in the new ILW store. The material to be retrieved, processed and stored includes: FED including Activated Nimonic Springs; FED solid assumed now to be sludge, Gravel, MCI and desiccant (treated as Wet ILW).						Refs: 21, 22,
2.3	Processing requirements		When the FED material is retrieved it is proposed to undertake further processing operations prior to the final encapsulation. This consists of the following: • Washing of the solid material to remove gross, loose contamination and transfer of the washings/sludge to the existing settling tanks within the AWV. • Gamma assay and inspection of the FED to enable significant fuel fragments, nimonic springs and other high activity items may to be removed (robotic device controlled by remote operator) for further processing prior to encapsulation. The location of the facility to separate out high activity items, will be based on operational and ALARP considerations. • Comparison of gamma analysis, with 'fingerprint' obtained from previous sampling and radiochemical assay studies. • Loading into cross-site transfer skip or final Nirex 3m3 box.	8	It is assumed that no significant pieces of fuel will be retrieved with the FED material. The quantities of fuel fragments found can be encapsulated with the FED material. The quantity of nimonic springs does not differ significantly from the upper estimate. Sufficient space will be available within the retrieval facility to locate the further processing options locally, if required.	If selected, any remote operated robotic device will be capable of visually identifying and picking up fragments of fuel and nimonic springs. If, due to space constraints, it is not possible to locate the processing facilities locally to the AWV, then they can be incorporated into the Solid ILW encapsulation facility. The proposed facilities and devices will be capable of the throughput of the retrieval facility and the encapsulation facility (i.e. will not create a bottle-neck).	Development work at Hinkley, Berkeley and Trawsfynydd will be continuously monitored to incorporate any significant design features, compatible with the Bradwell specific design. Following sampling studies, simulants specifications will be developed for use in potential equipment supplier demonstrations, to evaluate the option(s) selected, with respect to gamma inspection systems and robotic sorting devices. Further evaluation and size/layout development is required to assess the dose rates and confirm the proposed location of the processing units. Evaluation of suitable washing systems need to be undertaken for fines and adhered solid removal from the FED material.	R&D E R&D J R&D K
2.4	Encapsulation plant		The solid ILW waste will be encapsulated in compliant waste $3m^3$ boxes, with the lid having been secured using an automated robot with hole finding capability and torque sensing. The facility will contain a robotic swabbing station to monitor the package for contamination and a remediation position to undertake decontamination and	8	The facility will be designed to process the gravel, MCI and FED wastes. If it is required to process MAC, then additional shielding, if required, can be installed.	The layout and processing of the FED material can be undertaken within a fire suppression system. The facility can incorporate the additional processing if it cannot be undertaken,	Development is required to evaluate and incorporate a suitable fire suppression system, e.g. argon suppression or depleted oxygen.	R&D H R&D J R&D L

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
			remediation of non-compliant packages. Boxes will be filled with a cementitious grout at a grout station and allowed to cure prior to being capped with an inactive grout cap. Grout will be mixed using conventional construction industry plant. A facility for bleed water removal will be provided and a disposal route for excess grout and associated washings. The design of the facility will be based on operational units within Magnox. The number of grouting heads will be determined from throughput modelling. The plant will be combined with the Wet ILW Solidification process using the WAMH facility. The facility will be suitably shielded, and contain active ventilation systems, designed for the hydrogen evolution from FED encapsulation and fire suppression systems. Cement powders required for grout preparation will be stored in bulk silos or IBCs external to the facility.		It is assumed that the facility will be capable of incorporating the WAMH facility to enable Wet ILW to be processed in the same facility as the Solid ILW. It is assumed that a suitable lidding robotic system will be developed within Magnox South, with Hinkley or Berkeley as the lead site. It is assumed that a suitable package swabbing robotic system will be developed within Magnox South, with Hinkley or Berkeley as the lead site. The waste package will remain in-situ in the encapsulation / cap grouting station throughout the curing process. The supply of PFA and BFS powders, of the correct particle size and distribution, will be available from the market place at the time of operation.	local to the retrieval operations. The use low levels of organic superplasticisers in the encapsulating cement matrix, resulting in the use of a higher water/cement ratio continues not to be supported by the waste managing authority. The formulation of the cement grout is based on currently available PFA and BFS powders and has been tested on such.	Review of existing data for Solid ILW encapsulation and formulation development for an LoC submission. Perform R&D trials on a suitable stimulant to demonstrate grout infiltration for FED encapsulation. Progress the stability and use of superplasticisers and progress their use and approval with the waste managing authority. Development of handling, size reduction, formulation and waste compliant packaging systems for high activity items of MAC. Outputs from the Magnox South central developments in FED processing and disposal will be used, where applicable, for Bradwell site specific strategy. Review the combined design incorporated in the Hunterston facility for deployment at Bradwell.	
2.5	Cross Site Transporter		The system proposed for the Wet\ILW packages will be adapted for Nirex packages containing FED and other Solid ILW material, before and after encapsulation.	6	The Nirex boxes containing FED will be externally free of contamination to ensure the shielded overpack does not become contaminated. This could affect the transfer of completed packages to the ILW Store.	None envisaged.	See above for Wet ILW.	R&D F

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
2.6	Nirex Containers		Standard compliant containers ($3m^3$ Boxes and drums and 500 litre drums) will be used for the Wet and Solid ILW material. The waste boxes will be fabricated in Stainless Steel and contain twist lock grapple lifting features. The boxes will be handled, stored and periodically inspected to maintain a physical condition which will meet the Conditions for Acceptance to the Deep Repository.	7	The proposed box handling and inspection schemes will meet the waste repository requirements and be compliant.	The Conditions for Acceptance place technical and operational constraints on the construction, handling and storage of the container.	Outputs from the study conducted by Hinkley & Berkeley to simplify the design and fabrication of the $3m^3$ compliant waste box will be reviewed for applicability at Bradwell. Trials will be conducted to evaluate the benefits of grouting via a ported pipework system (with the lid in place) or directly through the lid aperture. Monitor the development work being undertaken centrally by Magnox South on stability to corrosion of the container during extended storage.	R&D L
2.7	Desiccant processing Development of a technical solution for the disposition of Desiccant is being undertaken by MEL W&D R&D project ref 10.39.35.39 / 39050.43.20		Desiccant will be retrieved from the gas drier units in the primary circuits and from drums stored in the AWC and decay stored in the ILW store in neoprene-lined 500 litre waste drums to inhibit tritium migration. It is proposed to immobilise the desiccant but currently there is no Regulatory approved BPEO for this waste stream. Waste characterisation data will be available to support any variations to the discharge consents to enable this waste stream to be immobilised in Cementitious (PFA/OPC blend) or Polymer based matrices.	6	A valid BPEO and potentially an increase in the site discharge limits for Tritium will be obtained during the C&M Preps or C&M phase. The 500 litre lost-paddle drums can then be processed by a modified LLWMSP, capable of handling these drums.	500-litre scale is the maximum for solidification of this waste. Larger scale produces increased cure temperature with increased tritium releases.	Further development work is required to establish a Regulator acceptable BPEO for desiccant immobilisation and submission of a LoC, if required. Review and progress development work on the encapsulation of Desiccant using a polymer based matrix, or transfer off-site to a high temperature incineration disposal unit. Potential processing in stainless steel 200 litre drums and secondary packing to comply with waste management requirements needs to be evaluated.	R&D N

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
2.8	MCI processing		Miscellaneous contaminated items (MCI) such as pond skips, ponds furniture, AETP and PWTP vessels, pipework etc., will be retrieved and, where necessary, safe and economic; decontaminated to allow disposal to Drigg as LLW. Decontamination to free release will only be done when this is ALARP and cost-effective. Any MCI that cannot be decontaminated for Drigg disposal will be encapsulated and placed in the ILW store, using the solid ILW encapsulation plant.	6	The items of MCI can be size reduced and processed to make all voidage accessible for grouting as ILW waste. An LoC submission will be accepted for these waste forms.	Suitable ALARP and cost effective methods will be available to process the MCI into a compliant wasteform.	Dependant on the waste characterisation, sampling and assay studies, techniques for size reduction and decontamination will be investigated for specific waste arisings.	R&D P R&D Q
2.9	Reactor Core Dust		The reactor core dust, which consists of graphite and fine particulates of activated material, is currently held in steel containers. The baseline is to immobilise the contents without opening the containers. Potentially, this consists of drilling an opening to inject a polymer. The container would then be treated as MCI.	3	It is assumed that this technique will produce an acceptable container for addition to a $3m^3$ box to produce a compliant package.	Acceptability of the use of free-flowing polymers by the waste management authority for the encapsulation of ILW. Handling techniques / systems for the small scale handling and immobilisation of small items of ILW.	Demonstration of the immobilisation of suitable simulants in the containers and their subsequent treatment as ILW waste in a full size Nirex package.	R&D P
2.10	Miscellaneous Activated Components (MAC)		Currently, the baseline strategy is to continue to store MAC arisings in their passive state within the Reactor pressure vessel or the Reactor quarter void storage areas. After the benefits of radioactive decay, conventional techniques for handling and encapsulating MCI can be used to process these items at FSC.	7	A Safety case can be constructed which supports the current storage facilities as providing passive safety for these items.	Accelerated FSC or processing of the MAC during C&M Preps phase would require the use of heavily shielded / remote retrieval and size reduction facilities, encapsulation plant and Nirex container.	Obtain sufficient information on the storage conditions and assay of the MAC to derive a Safety Case for storage. Review current techniques for handling, processing and encapsulation of highly active MAC waste.	R&D Q

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
3.0	**Ponds Decommission-ing**	**Overview:** The current scope of the Ponds decommissioning project is to complete the de-plant of the Cooling Ponds and the removal of the skips to enable the programme to continue with draining of the pond and removal and/or sealing of surface contamination. The scabbling operation will be determined following the review of the Trawsfynydd process and a contract placed for the detailed design and equipment supply and installation. The scope of the Ponds Decommissioning Project is to remove all of the fixtures and contaminated material from the Pond Buildings, to prepare the buildings for demolition followed by demolition of the structures. This includes the Ponds building, Ponds Water Treatment Plant (PWTP) and Active Effluent Treatment Plant (AETP), including associated settling tanks, pipework and pumps. The baseline strategy for this work is based upon the full decontamination, decommissioning and demolition work of the ponds at Berkeley Power Station. Details of the radiological decontamination and decommissioning techniques are referenced, as well as a possible decontamination and demolition strategy study conducted at Sizewell. In addition, current activities at Trawsfynydd, including the mechanical scabbling operations and LLW packing and disposal systems will be reviewed for inclusion in the strategy and techniques for use at Bradwell. All tasks associated with Ponds Decommissioning will be readily achievable using commercially available and proven technologies and methods, identified through appropriate BPM studies. ALARP will be applied to all radiation hazard tasks and may result in minor modifications to existing technologies to enhance worker protection. The demolition of the ponds and similar structures is expected to be undertaken under specialist contract.						31, 32, 36
3.1 TBA	Decontaminate Cooling Ponds Structure and transfer tunnels. Developed/ Detailed design and build	Remove fixed Pond Furniture	The depth of contamination into the concrete will be characterised (bore hole drilling for core samples) prior to removal of the contamination using mechanical scabbling methods as demonstrated at Berkeley and Trawsfynydd Power Stations. This waste will be disposed of as LLW to the national repository.	8	The bulk of the contamination from the ponds will be removed. The depth of the contamination will not exceed 40mm.	The deployment and geometry of the scabbling equipment and waste handling facilities will need to be reviewed for the layout of the Ponds at Bradwell. Techniques are still to be developed for removing contamination in joints and seams in the concrete structure.	Demonstrate removal using scabbling methods. Review further developments and operational lessons learnt at Trawsfynydd for suitability for deployment at Bradwell.	
3.2 TBA	Ponds Building structural decontamination	Decontam -inate Cooling Ponds structure.	After de-planting, the Ponds building structure will be radiologically surveyed and characterised to identify areas of surface and embedded contamination. Typically, contamination will be removed using manual techniques including percussion hammers and drills, scabbling heads and concrete planning devices. Sub-surface may be removed using boring and diamond wire/disc cutting systems. Final, large area surveys will be conducted to ensure the levels of contamination are minimal and remit conventional demolition techniques to be used.	8	It is assumed that local decontamination will enable the remaining structure to be demolished using conventional methods and procedures. BPM studies will be conducted to identify the techniques to be used based on the remaining levels of contamination in the structure.	The ability to undertake large area / volume radiological surveys to satisfy characterisation of the waste for consignment as free-release or LLW.	Develop techniques and trial to demonstrate suitable procedures for producing waste stream data for large volumes of waste with minimal contamination. Review further developments and operational lessons learnt at Trawsfynydd and Hinkley for suitability for deployment at Bradwell.	R&D T
3.3	Remove Ponds Water Treatment Plant (PWTP)	Clean and Drain Pond	Characterisation of the equipment and structures will be performed. Decontamination of equipment internals will be done using standard methods. The IX resin and pressure filter sands will be consigned to existing station facilities for processing and disposal.	7	Contaminated equipment and piping will be removed and size reduced typically using bag and cut methods.	Develop methods of flushing, hydrolasing or chemical cleaning for decontamination.	Further development work will be undertaken to cost effective decontamination techniques for the pond process equipment and structures.	R&D S

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					The resulting LLW will be processed through the site LLW Management facility.			
3.4	Remove Active Effluent Treatment Plant (AETP)	Decontam -inate Cooling Ponds Structure.	To enable the station AETP system to be removed, a mobile/modular unit (MAETP) will need to be installed to treat further active effluent arisings to the end of the C&M Preps phase. This will link into the Final Delay Tank/site active effluent discharge system. The MAETP will consist of Sand Pressure Filters, fine filters (cartridge type) and ion exchange abatement units. The unit will also consist of suitably contained holding/settling tanks. Facilities and access will be required for transfer of low activity waste by bowsers.	7	The consumable waste arisings from the MAETP will be LLW and can be processed by the site LLW Management facility. The mobile unit can be decontaminated and used on other decommissioning sites. Approval will be obtained from the EA for the necessary changes to the site discharge authorisation. All the main process items incorporated in the MAETP will be standard industrial units, currently available.	The specification for the unit will be interlinked with the potential facilities required for Wet ILW de-watering and if utilised, the abatement system installed with the FED Dissolution Plant. The Ponds decommissioning project will also remove the final delay tanks and active effluent discharge line. Alternative arrangements, incorporated in the installation of the MAETP, will be required.	Currently, Hunterston A and Trawsfynydd have procured MAETP units with significantly different specifications. The BPEO/BPM studies to select the Bradwell MAETP unit will review operational results of these units and any design/development work undertaken for the FED Dissolution abatement system. The future requirements for a replacement delay tank and discharge line will be developed to meet the site requirements and decommissioning schedule.	R&D S
3.5	Demolish Ponds Structure	Ponds Building Structural decontami nation.	Based on the Health Physics survey to establish the success of the decontamination, conventional demolition will be used wherever possible, using suitable supervision and containment techniques for potentially contaminated environments. Individual sections of the structure which may contain embedded contamination will be removed using diamond wire cutting techniques. The aim will be to create free-release material, balancing cost, schedule, ALARP and BPM concerns. The structure will be reduced to 0.5 metre below the final site level. Borehole samples will be taken through the floor structure of the Ponds to determine whether significant ground contamination is present beneath the structure.	8	Contained demolition of the structures within the building will be minimal. Techniques will be developed to survey the demolition waste on a large scale, to ensure that the waste is promptly classified and disposed off-site. Any further demolition of the structure below the envisaged depth, due to contamination of the ground, will be undertaken at final Site Clearance, if required.	The demolition work will be undertaken inside the RCA and will require Health Physics monitoring. The Ponds structure is physically next to the Active Waste Vaults. Demolition techniques may need to be modified.	Develop methods and procedures for ‘mass’ survey and consignment of demolition waste. Develop techniques for demolition to be undertaken in close proximity to working facilities.	R&D T

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4.0	**ILW Store**	**Overview:** The ILW Store will provide passive, safe and secure long-term storage for packaged ILW on the Bradwell Site until such time as the ILW can be transported off-site for final disposal in a National ILW repository. The ILW is currently awaiting recovery and treatment as outlined above, the majority of the waste being FED and Wet ILW. The ILW Store will be a new build, on unmade ground to the South of the Reactor buildings. The structure will be built on a piled reinforced concrete base, with approximately 1 metre thick reinforced concrete walls and roof to provide shielding and security. The concrete structure will be overclad with a proprietary steel and aluminium cladding system. The store will contain an import/export facility for handling the transfer of the Nirex packages to and from the shielded overpacks. The store internals will contain a package inspection facility, overhead crane to handle and stack the packages, shielded maintenance areas and an active ventilation system. The system will be based on the design currently being implemented at Hinkley A.						
4.1	Civil and structure		Ground improvements to the top 3-4 metres of the ground (currently consisting of site infill) will be required. This will consist of piling and substantial foundations for the base raft of the store. The remaining walls and roof will consist of reinforced concrete, with a sheeted over-structure to protect this from weathering during its 100 year design life.	8	The planning permission dimensions of 60m x 24m x 18m high will not be exceeded. The store will be designed to accommodate a maximum of 496 packages and will not require seismic qualification.	Suitable techniques will need to be deployed to identify and deal with sub-surface obstructions and the possible presence of Un-exploded Ordinances.	The design of the Cross Site Transporter (CST) and the ILW package overpack system will need to be integrated with the facilities within the store for the docking of the CST and the transfer of the package into the store.	R&D F
4.2	Mechanical Handling systems		The store will contain an overhead crane capable of lifting Nirex packages (up to a maximum weight of 12 tonnes) from the import area to the main storage vault and retrieving these packages for Periodic inspections and for final despatch to the Nirex repository. The package handling will consist of a 4-point twist lock grapple which will be able to handle Nirex $3m^3$ Nirex boxes and drums, and 500 litre drums in stillages. The long travel crane rails are designed to be maintenance-free and the power/control supply cables are reinforced with strain wires to enable the crane to be manually recovered. A service/maintenance area is provided for the crane, accessed via a labyrinth system and vertical hydraulic powered shield door.	7	The crane will not require extensive modifications as the radioactivity will be insufficient to cause damage to the equipment. The crane will not be replaced during the lifetime of the ILW Store.	The long travel crane rails can only be accessed using remote operated devices.	Further safety case substantiation development is required to enable a standard crane design to be used for this facility.	R&D U
4.3	Import and Inspection facility		A facility will be incorporated in the ILW Store to receive the Cross Site Transporter, accurately position the overpack and through shielding arrangements remove the package using the crane and transfer the package to the main storage vault area. The facility will also incorporate a shielded area where packages can be removed from the main storage vault area and placed for remote inspection. Suitable access points will be provided to introduce remote operated equipment to undertake these package inspections.	6	The overpack design and docking port in the store import facility will provide sufficient shielding during the transfer operation. The access to the import area will only require a roller shutter door, not a full shield door.	The docking arrangement must ensure that external dose rates at the boundary of the building and the site boundary are compliant with IRR requirements.		R&D F

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					The package surfaces will be radiological and chemically clean and will not require further inspections before transferring into the ILW Store.			
4.4	Maintenance of compliant storage conditions for the Nirex Packages		The conditions within the ILW Store need to be maintained to meet safety requirements and ensure the Nirex packages remain compliant with the Nirex CFA. The main criteria are: • Ensure Hydrogen released from the encapsulated FED packages does not create an atmosphere which exceeds 25% of the Lower Explosion Limit. (i.e. a concentration of 1% v/v in air). • Control the Relative Humidity to a specified level to ensure there is no free moisture on the packages. • Control the Chloride level to minimise potential corrosion of the packages. This will be achieved by the installation of a suitable re-circulating ventilation system. A portion of the air will be processed to maintain the store conditions in a compliant state. Visual inspection of the external surfaces of the packages will be achieved by mounting CCTV to the crane assembly, for deployment between the package stacks. The layout of the package stacks will provide sufficient clearance for deployment.	7	It is assumed that the ventilation system will be run continuously during the filling phase of the store but will only be required intermittently during the C&M phase, dependant on the ambient conditions.	The installed equipment within the main storage vault will need to be maintenance-free. Monitoring equipment will need to be installed to allow retrieval for maintenance, calibration and replacement. Application of MAGGAS model to predict the gas evolution from cemented waste.	Based on hydrogen evolution data from encapsulated FED packages, store ambient conditions etc., the requirements for a permanently installed ventilation system will be evaluated. A suitable deployment device and radiologically hardened CCTV system will be developed to enable in-store visual inspection of the packages to be undertaken.	
4.5	Periodic Safety Review and package inspection		Throughout the storage phase of the ILW packages during C&M, it will be necessary to recover packages and materials for inspection. This is required to demonstrate the ongoing condition of the packages is still Nirex compliant. The packages will be recovered using the installed crane and twist lock grapple.	7	It is assumed that suitable dummy packages will be used, positioned for easy retrieval, to provide the required information. Recovery of active packages will be minimised.	Development of a model for the ageing and durability of cement matrices based upon accelerated testing. The store will need a Nirex LoC and NII Licensed Instrument to be built and continue operation for up to 100 years. Use of installed equipment to recover packages for inspection. Existing construction arrangements for the inspection cell.	Corrosion assessment of containers of cemented wastes to determine lifetime storage parameters. Determine the requirements for dummy packages and material coupons to underpin the Periodic safety Review and inspection and compliance audits for the store. Evaluate the effects of package movements on corrosion models.	

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5.0	**Radiation Controlled Area (RCA) De-plant and Demolition**	**Overview:** There are a number of facilities within the RCA that will be deplanted and demolished during C&M Preps. The majority of the plant within the floors of the Reactor Building itself will also be deplanted although the reactor building itself will be left standing. Industry specific techniques will be governed by working in accordance with regulatory requirements. Radiological and other hazard characterisation will be undertaken. Isolations will be made in accordance with the Magnox Electric Safety Rules and Guidance from the Ionising Radiations Regulations (IRRs) Code of Practice. Radiological, chemical and industrial hazards will be removed to enable subsequent deplanting and demolition of the facilities. In the reactor building, sections of plant can be isolated as they cease to be required for operational purposes. However, as the opportunities for the use of wholesale isolation techniques, as used in the turbine hall de-plant, will be less and with the additional restrictions imposed by radiological conditions, the decommissioning and removal of plant within the RCA will be more involved.						
5.1	Preparations		Station Staff will supervise and potentially undertake the majority of the safety case preparation, plant isolation, and post operational clean out (POCO). Contaminated and non-contaminated asbestos will be removed using standard practice but additionally for potentially contaminated asbestos, characterisation will determine the subsequent management of the material. Oils will be drained from the equipment into drums and bowsers for processing and off-site disposal to licensed contractors.	9	The removal of thermal insulation, whether inside the ISB or outside, will all be done using specialist contractors.	.		
5.2	Boilers	De-fuelling	The operation to remove and dispose of the asbestos thermal lagging is in progress. When the boiler areas are certified as asbestos-free, the deplanting and removal of the conventional wet side boiler equipment and plant can commence, up to the boundaries of the Turbine Hall de-plant project.	9	It is expected that the radiological considerations of the boiler wet-side decommissioning will be minimal, comprising potentially contaminated thermal insulation and pipework surface contamination.	Care will have to be taken within the boiler houses to preserve the primary system boundary, the boiler shell and gas ducts, until permission is given to permanently breach the pressure circuit for final decommissioning.		
5.3	Active Plant	Boilers	The gas circulator systems, including associated oil systems, will be decommissioned following the boiler pipe work and equipment. The bulk of this equipment will be contaminated due to contamination of the oil used to form the seal from the primary circuit. The oil will be disposed off-site using current contracts in place for this waste stream. The removal of the boilers, primary gas circuit ducts and charge face equipment is described in the Back to Bioshield project.	8	Station Staff will supervise the Post Operational Clean Out and some preliminary deplanting of active plant inside the RCA at the start of the decommissioning period. The bulk deplanting of the boiler house equipment, gas circulators and other "conventional" plant inside the RCA will be undertaken using external contractors.	The presence of radiological contaminants within the oil will increase the difficulty of plant removal. The cleaning and decontamination of the considerable quantities of small-bore pipe work is problematic, and much of the equipment may be disposed of as LLW.	Development work is being undertaken to develop easier methods of activity characterisation & decontamination techniques, especially for pipe work, for the active plant.	

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5.4	Non Active Plant	De-fuelling	The remaining plant systems within the reactor building comprise conventional electrical distribution items, and mechanical systems such as cooling water, compressed air, and diesel generators. This will also include Pilecap deplanting. Once cleaned and decontaminated, which is not expected to be difficult, most of these plant items will join conventional waste streams.	8	None of these routinely contain active components, and radiological concerns are expected to be limited to external surfaces.	If present, MAC waste within the pile cap equipment will require remote operations due to the expected high activity levels.	Further characterisation of the pile cap equipment to determine the levels of activation and contamination. If required, develop remote devices to remove, handle and process the MAC waste.	R&D Q
5.5	Buildings	RCA De-plant	Once deplanted, characterisation of the remaining building structures will be undertaken to ascertain extent, area and depth of contamination and determine if decontamination to free release is possible, practical and cost effective.	8	Further work will be undertaken to further examine demolition techniques for the pond and similar structures, such as contained demolition	If free release is practical, perform pilot demonstration to establish methods and cost.	Quicker decontamination and contained demolition methods will reduce cost and increase free release or on-site disposal volumes of waste.	R&D T R&D V
5.6	Waste		Wastes will be disposed of in accordance with the sites Best Practicable Environmental Option (BPEO) for conventional and/or contaminated wastes. Radiological decontamination will be undertaken using standard abrasive methods typically used in mechanical deplanting of equipment, piping and ductwork e.g. grit-blasting. After best decontamination effort to reduce radiation hazard, controlled dismantling methods will be used for removal of contaminated equipment and piping, typically using bag and cut methods.	8	Evaluation of the waste and amounts of decontamination required would balance cost, schedule, As Low As Reasonably Practicable (ALARP) and Best Practicable Means (BPM).	Determine how much additional decontamination is required to lead to either conventional demolition or contaminated demolition, based on results decontamination and additional characterisation.	Development work is being undertaken to develop easier methods of activity characterisation, especially for large surfaces or volumes.	R&D T
6.0	**De-plant and demolition back to Bioshield**	**Overview:** The Back to Bioshield (BoB) strategy is seen as an enabling project for the acceleration of Final Site Clearance. It is also delivers socio-economic and cost benefits for the C&M phase. The project consists of the removal of the boilers and gas circuit primary ducts including the Circulator Hall structures and Reactor building annexes. The Charge face equipment will be removed to enable the height of the Reactor building to be reduced. A simple, weather-proof cladding roof will be constructed above the charge face area.						
6.1	Structure removal	Asbestos removal	The structure and cladding housing the boilers and Circulator Hall equipment will be removed. This will allow the mechanical equipment to be accessed for retrieval.	9	The structures are not load bearing or integral to the stability of the equipment	The operations will be undertaken in close proximity to other operations or active processes. The access will be restricted.		
6.2	Mechanical De-plant	Structure Removal	Conventional heavy-lift equipment would be used to assist in the removal of the boilers, associated plant and pipework, primary circuit gas ducts, associated by-pass and filtration plant, blowers and circulators. These would be sealed, surface contamination removed and placed in a controlled lay-down area to benefit from radioactive decay.	9	Access can be made to deploy the lifting equipment and remove the boilers and other large items. The level of external surface contamination is minimal or can be suitably	Suitable lifting equipment is available that can be deployed in the restricted access.	Engage with specialist contractors and Station Health Physics specialists to determine any further surveys and characterisation to be undertaken to underpin and develop de-planting methods.	

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			The R1 and R2 units will be sealed at the main isolating gas valves.		decontaminated to enable de-planting to proceed under C2 conditions.			
6.3	Final off-site disposal	Mech. De-plant	The de-planting process will generate several thousand tonnes of carbon steel material. The material will be surveyed, decontaminated where feasible, ALARP and cost effective to segregate as free release material. The remaining material will be decontaminated and processed for subsequent re-cycling options. Currently, controlled smelting systems are under consideration.	6	The material will be size reduced on site for shipment to a smelting/processing works or will be transported piecemeal, if suitable methods are available.	To be feasible, it is envisaged that a UK based smelting facility will be required. There will be significant challenges to social and regulatory acceptance for the transportation of this material and the construction and operation of a treatment plant.	The development of this strategy is being undertaken by Magnox South, and site specific inputs from Bradwell will be included. Characterisation studies and Health Physics surveys will be required to provide further under-pinning data.	
6.4	Safe Store Preparations	Mech. De-plant	After demolition of the Circulator Hall structures and de-planting of the Charge Face, the roof above will be lowered and a new roof structure installed. The remaining building structure will be protected by repairing or replacing the cladding arrangement as required.	6	The experiences gained at Berkeley and Trawsfynydd will be utilised to design the secondary charge face roofing and the cladding arrangement. The cladding is assumed to have a life of 30 years. Cladding replacement and periodic safety checks on the structure will be required.	Predicted lifetimes of cladding and concrete treatments are not known to cover the expected 30 year lifetime.	Actual data is required for the longevity of the proposed cladding panels.	
7.0	**Conventional Plant Area De-plant and Demolition**	**Overview:** After personnel have been withdrawn to areas outside the site security fence, the areas outside the RCA have been made redundant, vacated and isolated; they will be able to be decommissioned using conventional demolition means. These facilities will be surveyed and characterised to remove and isolate hazards such as asbestos, electrical supplies and oils and chemicals. The entire area will be islanded from the Reactor systems within the RCA. Plant, equipment, structures and buildings will be removed using standard industry techniques involving both manual and mechanical means as deemed appropriate. Recycle and reuse of materials will be maximised. The CW Systems will be demolished as part of the conventional plant disposal. The offshore structures will be removed to 1m below seabed level. The tunnels external to the site boundary will be made safe, in a manner to be agreed, such that the public would not be put at risk from inadvertent structural collapse. Tunnels and other voids within the site boundary would be backfilled and sealed with rubble and concrete as appropriate. Consideration is being given to the development of an engineered on-site waste disposal facility for certain categories of waste. Boundaries, scope and end state are still to be defined. Work packages will be appropriately tendered and contracts let. Demolition will be performed using industry standard techniques, with structures being reduced to a level 0.5 metre below the site ground level.						
7.1	Characterise and hazard removal		These facilities will be surveyed and characterised to assess hazardous material content, scope of work, risk assessments etc. A hazard reduction campaign will be carried out to remove and isolate hazards such as asbestos, electrical supplies, chemicals and oils.	9	Disposal routes will be available for all hazardous material identified.			

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			Hazard management strategies will be developed for the hazard removal phase and in conjunction with the contractor, the main demolition phase.					
7.2	Isolation: Removal of the Plant from the System	Characterisation and hazard removal	Isolating and islanding the conventional plant areas made redundant to allow for demolition. All services will be disconnected to enable the building and associated plant to be removed from the site systems and excluded from the requirements of the Magnox Safety Rules. The facility will be handed over to a specialist contractor to complete the hazard removal and commence the demolition.	9	This work to be jointly undertaken by Station Staff, directly supported by additional specialist contract labour.			
7.3	Conventional Demolition	Isolation	Numerous items of plant and buildings outside the RCA require demolition during the C&M Preps phase. Deplant & Demolition of the Turbine Hall will be a major activity within this area. Demolition of the facility will result in a significant 'void' (~44,000m^3) within the turbine hall basement. Within this technical baseline the void will be in-filled with non-hazardous (inert) demolition wastes such as building rubble and soil. Removal of Station Transformers has been completed and the work has been basically self-funded from the scrap value.	9	Conventional demolition practises will be used throughout the project and voidage backfilled using inert demolition wastes.	Demolition to an agreed brown/green field site condition, and possible engineered waste disposal facility		
7.4	On-site storage		An engineered on-site waste disposal facility for certain categories of waste, such as inert LLW, thus reducing the amount disposed off-site to the LLWR facility at Drigg and the amount of backfill required to be brought onto site.	3	This proposal is only at the conceptual stage, and work will be undertaken to agree, examine and develop the possibilities for on site disposal.	Definition of the end point, to continue the demolition to an agreed brown/green field site condition, or to convert a structure into an engineered waste disposal facility.	It is necessary to obtain a number of approvals and authorisations prior to any possible implementation. This site specific work would be supported by developments being undertaken centrally by Magnox South.	R&D V
8.0	**Contaminated Land and remediation**	**Overview:** The nature and extent of radioactively and other (such as Hydrocarbons, asbestos etc.) contaminated ground (and/or groundwater) varies greatly from site to site (and within sites). Bradwell will continue to generate sufficient characterisation data for areas of contaminated ground on the site. This will aid the selection of the preferred option(s) to ensure passive safety during Care and Maintenance and takes account of the intention to de-license the site at the end of Final Site Clearance.						
8.2	Remediation	Sampling and characterisation	Any contamination found is managed in accordance with the relevant regulatory regimes mostly administered by the Environment Agency. Non-radioactive contamination is not directly relevant to eventual de-licensing of sites, but may influence future land use.	6	The Company has a contaminated land Intelligent Customer capability that will be consulted on the application of guidance information on	Excavation and removal requires consideration of the options for treatment, storage and disposal of the resulting waste (typically very low activity LLW	Retention of residual contamination in the ground requires a safety case for the duration of C&M.	Dependant on the extent and type of contamination found, the strategy and

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
			The main strategy options include: • Removal of contamination (e.g. by excavation); • Enhanced containment *in situ*; • Monitoring the contamination *in situ* without engineered enhancement of containment.		contaminated land and the engagement of external contractors to manage this contamination.	dominated by Cs_{137}). Existing underground Active drains will need to be immobilised into a passive state.	Techniques for sealing / and or remediation of underground active drains will need to be developed and progressed. Strategies will need to be developed to address the possible remediation techniques required, dependant on the bore-hole sampling results.	appropriate safety case will be developed.
9.0	**Care & Maintenance**	**Overview:** The end state of the site following completion of the C&M Preps phase will comprise of the reactor building in safestore that will contain the ILW store, the laydown and interim storage facility for the boilers and primary circuit ductwork, and those services required to operate the site through the C&M period' including the Gatehouse, Site Monitoring Facility (SMF), electrical sub-station and fire ring main. All other buildings will have been demolished to ground level; voids filled and made safe, and the site partially landscaped to ensure that no hazards, e.g. water hazards, may collect over time. The remaining hazards on the site, the reactors, primary gas circuit components within the Bioshield and ILW store will be in a safe, secure, fully contained, protected and robust condition for the duration of C&M to allow radioactivity to decay to lower levels prior to FSC. Packaged ILW will be removed from site to a National ILW repository when it becomes available.						
9.1	C&M maintenance	Safe Store Preps	The site will be in a passively safe state requiring minimal human intervention as most hazards, including those that were the most active and potentially mobile, will have been removed or immobilised. Cladding panels that make up the roof of the safe store of the reactor building will be replaced at 30 year periods. The Site Monitoring facility will be manned to monitor alarms and facility status. Periodic walkdowns of the site will identify visual impacts.	7	Initially, during the C&M phase the site will be manned. The site facilities will be routinely monitored and will undergo more extensive investigation during the Periodic Safety Review (PSR). The strategy for continued manning and operation of the site will also be reviewed. Alarms and indicators will not be transferred to a central facility for monitoring. The Periodic Safety Reviews (nominally at 10 year intervals) will not reveal any extensive remediation work.	Mobile facilities will be required for personnel to access the contaminated areas within the RCA for more extensive inspection and works. Activities will be controlled by the C&M Safety Case submission. Existing Site License conditions require the security and integrity of the site to be managed.	Development is required to establish suitable finishes for the existing external concrete finish of the Reactor buildings. Develop the interim storage conditions for the boilers and ductwork removed from the Reactor buildings, prior to final disposal. Develop substantiations to support the proposed Safety Case and the site maintenance and manning implications.	

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10.0	**Final Site Clearance**	**Overview:** At the end of the FSC period all of the radioactive structures, including those below ground level, will have been removed from the site and all structures removed to at least ground level with any below ground level voids back-filled where necessary for safety reasons. Any remaining significant ground contamination will have been removed. Finally, the Site will be subjected to extensive radioactivity surveys to confirm that no unacceptable radioactivity remains on or below the site and that the site can be de-licensed.						
10.1	Preparatory Works and Access Reactor Pressure Vessel	Back to Bio Shield	Necessary site infrastructure is re-introduced to the site to support Final Site Clearance including necessary waste handling facilities, services, accommodation, encapsulation plant etc. Modify concrete bioshield to facilitate access routes for retrieval plant and waste removal. Remove control rods and other long items from reactor core and surrounding voids. Open access routes into the space between the steel Reactor Pressure Vessel (RPV) and the concrete bioshield. Break through the pile cap and into the RPV.	6	A containment building will be constructed over the pile cap area. All thermal lagging will be removed using conventional industrial procedures. Conventional industrial diamond drilling and cutting procedures will be used. The concrete bioshield will still retain sufficient structural integrity to support the required modifications.	Access into the voids (such as RHF, NCAW, CAW, reel and filter voids) surrounding the reactors may only be possible after the Reactor dismantling has been completed.	Currently a feasibility study is being conducted to determine the site-specific enabling works required under the proposed 25 year FSC strategy	
10.2	Preliminary Reactor Dismantling		Erect containment between the top of the RPV and the newly formed sides of the penetration in the pile cap. Progressively remove the Guide Tube Assemblies Install lighting and Closed Circuit Television (CCTV) in the RPV. Lower two Remote Handling Machines (RHM) through hole at top of RPV onto graphite core. Cutting and size reduction operations to be executed using the RHMs.	6	Remote Handling Machines (RHM) to be used in the RPV are presently based on proprietary equipment such remotely operated Brokk vehicles. It is assumed that the radiological activities will not preclude the manual removal of the thermal insulation from the upper sections of the RPV.		Development and implementation of the project strategy.	
10.3	Graphite Removal		RHMs to remove the reactor core moderator bricks starting at centre and working outwards. Brick removal to be repeated layer by layer until the base level diagrid is reached.	7	Displaced bricks to be transferred in skip to the pile cap for disposal via the newly constructed waste processing facilities and available waste routes.	The National Deep Depository will accept the contaminated Graphite and will have sufficient storage capacity.	Disposal route for irradiated Graphite to be identified and agreed with regulators and stakeholders.	

Task / Process ID.	Task/Process description	Preceding task	Technique	TRL	Assumptions	Technical constraints	Gaps (ref to R&D table)	Key reference documents
10.4	RPV Dismantling		Sides of RPV cut away down to the diagrid level. Discarded material to be transferred to the pile cap in skips and disposed of via the existing waste facilities and waste routes.	7	The RPV will be cut away using conventional industrial procedures utilising the external scaffolding/staging.	The dose rates, potential contamination levels and conventional safety concerns, will necessitate the use of remote operations.	Categorisation of the quantity and activity of the waste being generated. Development and optimisation of cutting and handling techniques during the operations.	
10.5	Reactor Support Structure Dismantling		Remove the diagrid and remaining steelwork located in the void below the RPV. Discarded material to be transferred to the pile cap in skips and disposed of via the existing waste facilities and waste routes.	7	The removal the diagrid and remaining steelwork will be done using conventional industrial procedures.		Categorisation of the quantity and activity of the waste being generated. Development and optimisation of cutting and handling techniques during the operations.	
10.6	Radial Shield and Bioshield Removal		Remove the radial concrete shield and then remove the inactive concrete bio-shield. Survey and monitor remaining building structure, decontaminate as appropriate and demolish utilising industry standard techniques.	7	Removal of the concrete structures will be done using conventional industrial / demolition procedures. That the current estimate of the depth of contamination of the concrete is representative of the whole structure.		As access becomes available, take further core samples to accurately determine the depth of contamination. Development and implementation of the project strategy.	
11.0	**Site End State**	**Overview:** The end-point of the FSC period is therefore assumed to be a de-licensed green field site with all structures removed to at least ground level, landscaped and planted with appropriate locally indigenous flora thus allowing the site to be made available for any alternative appropriate use.						
11.1	Contaminated Land	Final Site Clearance	Non-radioactive (chemical) and Radioactive ground contamination characterisation, monitoring and site hydro-geological mapping work will be carried out. Any contamination found will be removed or contained, dependant on the agreed site end state.	7	It is assumed the site end state will be green field, requiring the removal of all contamination.	Excavation and removal requires consideration of the options for treatment, storage and disposal of the resulting waste.	Adequate characterisation and understanding the end state is essential to ensure that the correct amount of remediation is done and the site can be de-licensed.	
	Landscaping		The land will be landscaped to make it acceptable for future usage.	9				

Table 1B: Bradwell Decommissioning Site - Technical Baseline: Changes from FY2007 – 2008 submission

Task/Process ID	Task/Process Description	Identification of Change	Impact of Change
Ponds Decommissioning Task 3.3 Clean and Drain Pond and Transfer Tunnels	The Ponds will be drained and a fixative applied to support further decontamination.	Modification of process. TRL has decreased from 7 to 6	It is now proposed to apply the fixative/sealant as the Cooling Pond is being drained. This process has been researched/developed in the USA, but a practicable solution needs to be demonstrated on a larger scale. Previously the system was to be applied when the Cooling Pond was fully drained.
Ponds Decommissioning Task 3.4 Fuel Skips and mobile Ponds furniture	The skips will be removed from the Ponds, processed to reduce them from ILW to LLW wherever possible, so they can subsequently be disposed of to the National LLW Repository near Drigg.	Task complete. Skips are loaded in HHISO containers for potential shipment to the National LLW Repository.	TRL has increased from 6 to 9 as the task is complete.
Radiation Controlled Area (RCA) De-plant and Demolition Task 5.1 Preparations	Contaminated and non-contaminated asbestos will be removed using standard practice but additionally for potentially contaminated asbestos, characterisation will determine the subsequent management of the material. Oils will be drained from the equipment into drums and bowsers for processing and off-site disposal to licensed contractors.	Modification of Process to completion. TRL has increased from 8 to 9.	The processes have been implemented. The Environment Agency has approved ‘activity averaging’ therefore suitable disposal routes are available for contaminated and non-contaminated asbestos. Self-performed work on the deplanting of the Circulator Halls has identified the minimal extent of radioactive contamination of the oils and therefore suitable disposal routes are available for contaminated and non-contaminated oils.
Contaminated Land and Remediation Task 8.1 Borehole sampling and Characterisation	Further borehole sampling will be undertaken within the RCA to provide a more complete picture of any contamination. This will later include borehole sampling through sub-surface structures (e.g. Cooling Pond, Active Waste Vaults) when the main structure demolition phase is complete.	Substantial completion of task. TRL has increased from 6 to 8	The borehole sampling has been completed and a 6 monthly sampling routine has been put in place. An initial Contaminated Land management strategy has been determined. Further sampling will only require ‘boring’ techniques to penetrate existing concrete structures to create boreholes for further monitoring data.

Table 2: Bradwell Research and Development Table.

Generic R&D work is being undertaken and managed through the Decommissioning Strategies Organisation (DSO) and the Reactor, Waste & Decommissioning Technology Group (RWDTG). Strategies will be implemented at BNLS as appropriate. Details of the 2008 - 09 generic R&D work can be found in the Magnox Electric Ltd Waste Decommissioning Research & Development Programme.

Task ID	Technical need - task + gap	Context of why a problem	Target Date	Cost range	Needs / Risks / Opportunity	Site / Generic / NDA issue	Key outputs / Actions
R&D 1	FED vault waste retrieval mechanism.	To provide confidence that the equipment design is suitable and will meet the throughput requirements. Development of a spray wash system to ensure any loose contamination is removed from the grab, prior to transfer across the Retrieval cell, to prevent the spread of contamination.	June 2008 (for initial trials) Mar 2009 (for further trials if dissolution continued)	<£50k £50k to £100k	Immediate Need		Concept design has identified a typical proprietary arrangement consisting of a telescopic mast and a Brokk arm device mounted with various end effectors. Progress of retrieval system design at other Magnox sites will be monitored, including designs produced for projects at Sellafield. The potential to collaborate on trials currently being conducted by other sites will be progressed and lessons learnt will be incorporated and integrated into the site-specific design solution for Bradwell. If Dissolution is accepted as the technical baseline and progressed, then in conjunction with the potential equipment manufacturer(s), where cost effective and practicable, a test rig and mock-up trials will be undertaken with simulant material.
R&D 2	Identify and model the ventilation/Oxy-Reduct system for flow and dispersion through the stored FED material.	To substantiate the viability of the deployment of the Oxy-Reduct system to provide fire suppression in the FED storage vaults, the gas flow and dispersion model will need to be developed. Further R&D may be required to modify the design and therefore the model developed. The design will need to be integrated into the ventilation system providing the negative pressure to maintain the containment of the Retrieval Module.	June 2008 Mar 2009 (for further development if dissolution continued)	<£50k £50k to £100k	Immediate Need		The system will be developed in conjunction with lessons learnt from the design and deployment at Hunterston A. This will be integrated into the concept design development for the deployment arrangements at Bradwell.
R&D 3	FED vault waste retrieval mechanism, effectors tooling systems	To provide confidence that the equipment design is suitable for the retrieval of FED, gravel, sludge retrieval equipment deployment and miscellaneous debris.	June 2008 (for initial trials) Mar 2009 (for further trials if dissolution continued)	<£50k £50k to £100k	Immediate Need		In conjunction with the manufacturer of the end effectors unit, develop suitable tools to undertake the specific retrieval tasks. Using the test rig above, demonstrate the suitability of the equipment. Progress of retrieval system design at other Magnox sites will be monitored, including designs produced for projects at Sellafield.
R&D 4	FED throughput and processing requirements. Review of FED characterisation studies on process parameters and design solutions.	The concept design for FED Dissolution, is based on theoretical data and limited physical characterisation. On-going vault sampling, characterisation and radionuclide assay will provide accurate design data which may affect the current concept designs.	June 2008 Mar 2009 (for further development if dissolution continued)	<£50k £50k to £100k	Immediate Need		On completion of the FED vault sampling and analysis, key design studies will be required. Development work will be required to optimise the design of the reaction vessels associated with the Dissolution plant and the control of the reaction rate (based on FED supply or acid addition systems) and the resulting Hydrogen

Task ID	Technical need - task + gap	Context of why a problem	Target Date	Cost range	Needs / Risks / Opportunity	Site / Generic / NDA issue	Key outputs / Actions
							evolution. This data can then be used to develop the design of the Active Ventilation system in the Dissolution module and maintain the Hydrogen level below 1% vol/vol in air.
R&D 5	Solid ILW Sorting – development of a system to indicate and enable removal of high activity components.	Current optioneering indicates that segregation of nimonic springs and fuel fragments from FED splitter material is ALARP & BPM. The concept design considers the use of a high resolution gamma detection device to detect and locate these items. This principle needs to be evaluated for the design development. This detection system will need to provide sufficient data to enable a remote operated robotic arm to be able to retrieve these items.	June 2008 Mar 2009 (for further development if dissolution continued)	<£50k £50k to £100k	Immediate Need		BWA is to progress the review of current systems deployed at Trawsfynydd and designed for Berkeley and Hunterston. Lessons learnt will be incorporated in the development of the concept design and evaluation trials may be required to substantiate the design. Further evaluation trials for the operation and tooling of the robotic arm may be required with the potential equipment supplier(s).
R&D 6	Discharge Abatement System – development of a system to incorporate fine filtration and soluble activity removal using an Ion Exchange media.	The BPEO for Bradwell site is the dissolution of FED solid and sludge with suitable abatement to minimise the active environmental discharges. The dissolution acid selected in the BPM study was Nitric Acid. Theoretical calculations have indicated that the discharges from this system will comply with our current discharge consent and will demonstrate BPM and ALARP compliance. This needs to be substantiated.	June 2008 (Initial data from trials) Mar 2009 (for further development if dissolution continued to optimise the IX resin selection)	<£50k £50k to £100k	Immediate Need		The ILW Characterisation project has provided samples of active FED to undertake lab scale trials. Further design and trials to underpin and substantiate the discharge activities is required to verify the theoretical discharge predictions in support of the BPEO study. Dependant on the above trials, further trials will be required to optimise the selection of the IX resin and the fine filtration system. Trials will be required to ensure that a compliant ILW waste form can be produced from the waste and a CLoC can be submitted to RWMD.
R&D 7	Ponds Active Ventilation System	Current deplanting activities in the Ponds complex have been achieved using a temporary arrangement with portable HEPA filtered MFUs which has been developed using field trials and advice from the Intelligent Customer for Active Ventilation Systems. The Ponds de-planting and skip cleaning/removal phase has augmented the existing ventilation arrangement with portable units, re-circulating the air through HEPA filters. The suitability of this arrangement for current and future operations needs to be established.	Sept 2008	<£50k	Immediate Need		A design study will be undertaken to review the Active ventilation requirements for all phases of the Ponds de-plant, decontamination and decommissioning. The arrangements at Trawsfynydd and design options for Hinkley will be reviewed. A BPM solution will be derived for the ventilation arrangements.
R&D 8	Removal of surface gross contamination and removal of remaining sludge	It has been assumed that the majority of the surface contamination of the Ponds can be removed using pressurised water jetting. This contamination and the remaining pond sludge needs removing. It is assumed that this can be removed by proprietary pumping systems or possibly by modifying the ponds chemistry to dissolve the sludge. These assumptions required underpinning and substantiating via field trials.	Sept 2008	£50k to £100k	Immediate Need		Lessons learnt from the Opportunity for Dissolution project and the skip cleaning project will be evaluated. Field trials will be undertaken to demonstrate systems, techniques or equipment to meet these needs.

Task ID	Technical need - task + gap	Context of why a problem	Target Date	Cost range	Needs / Risks / Opportunity	Site / Generic / NDA issue	Key outputs / Actions
R&D 9	Drain Ponds and transfer tunnels and apply surface sealant	From Lessons Learnt from the Trawsfynydd Ponds project, to enable a simpler Active Ventilation system to be used and facilitate the remaining deplanting and scabbling it is assumed that the sealing of the Ponds structure surfaces during draining will achieve this objective. Although suitable sealants are available, this novel application needs to be developed.	Sept 2008	£100k to £1M	Immediate Need		Current developments in the USA and Europe will be monitored and evaluated. Development work and appropriate field trials will be undertaken to evaluate the potential options.
R&D 10	Off –Site Disposal options – Metal Smelting	The deplanting of the Cooling Ponds and the removal of the Fuel skips will create a large volume of LLW waste for disposal to Drigg. The cost and use of a limited resource could be mitigated by sending the material to an overseas facility for processing.	Dec 2008	£50k to £100k	Immediate Opportunity		In conjunction with strategy developments being undertaken by Magnox South, BPM justification is required for the off-site disposal to metal smelting facilities for re-use and recycling of contaminated steel waste. Characterisation information is required to scope the level of contamination in fixed Ponds Furniture, following ALARP decontamination activities. Samples need to be generated for trial shipments and processing to check suitability. Temporary interim storage arrangements size reduction requirements and off-site transportation arrangements need to be developed.
R&D 11	Decontaminate Cooling Ponds Structure and transfer tunnels, Concept Design phase only. Characterisation	The concept Basis of Design assumptions currently are based on data from Berkeley and Trawsfynydd Cooling Ponds, and structural drawings from the construction of the Cooling Ponds at Bradwell. It is assumed that the Reinforcing bar within the concrete structure is more than 50mm below the surface. It is also assumed that the contamination has not significantly penetrated more than 40mm into the concrete and that the removal of the first 50mm will be sufficient to decontaminate the Cooling Pond structure to an acceptable level. Therefore a concrete coring survey and radiochemical assay programme is to be undertaken.	March 2009	£100k to £1M	Immediate Need		A survey of the Concrete structure of the Cooling Ponds needs to be undertaken, and a sufficient quantity of cores taken at appropriate positions. These cores need to be transported off-site for radiochemical assay. This data will be used to confirm the construction details of the Cooling Ponds and provide data for the Waste Stream Characterisation Document (WSCD) to enable the scabblings to be consigned to the LLW repository.
R&D 12	Decontaminate Cooling Ponds Structure and transfer tunnels, Concept Design phase only. Activity	The current concept Basis of Design is based on the existing Ponds scabbling activities at Trawsfynydd. The development of the Concept design will require extensive optioeering studies, peer review of available technologies and some trials and development work to evaluate the techniques for their suitability at Bradwell	March 2009	£100k to £1M	Immediate Need		The Peer review, technology searches, equipment demonstrations and trials will provide data to undertake the optioneering and substantiate the BPEO studies.

Table 2A: Bradwell Research and Development Table. R&D work on hold during FY 2008/2009

Task ID	Technical need - task + gap	Context of why a problem	Target Date	Cost range	Needs / Risks / Opportunity	Site / Generic / NDA issue	Key outputs / Actions
R&D A	Wet ILW Retrieval equipment. Identify and trial techniques for slurry handling and access for deployment of equipment	To provide confidence that the equipment design is suitable and will meet the throughput requirements to retrieve sludges and Ion Exchange resins from their respective settling tanks, located in the Active Waste Compound. Investigation and trials for creating equipment access points for deployment in the IX resin settling tank in an ALARP manner. This will include methods for installation of the equipment.		£50k to £100k	Need		Retrieval equipment currently being reviewed and substantiated. Optioneering reports & experience from other sites currently being reviewed to enable selection of most appropriate option for BWA. Lessons learned from Vault 6B retrieval project to be progressed for the contents of Vault 6A. Organise trials of cutting equipment or similar for steel tank. Investigate availability of suitable equipment. Investigate equipment deployment methods to meet ALARP requirements.
R&D B	Wet ILW storage prior to conveyance. Survey and potential replacement of existing settling tanks.	It is assumed that the current and future arisings of Wet ILW sludge and IX resins can be settled, interim stored for assay etc., utilising tanks 62V, 61V and 56V. Until all the sludge is retrieved from tank 62V and an internal inspection undertaken, the suitability for re-use of 62V and possibly 61V cannot be determined.		£100k to £1M	Need & Risk		A method for inspecting 62V internally needs to be developed. Subsequently a throughput modelling exercise is required to demonstrate the design robustness of requiring only 3 tanks, based on varying scenarios.
R&D C	Wet ILW Conveyance and Transportation equipment	To provide confidence that the equipment design is suitable and will meet the throughput requirements to transfer the wet ILW from the settling tanks to the location of the Processing plant.		£50k to £100k	Need		Conveyance equipment currently being substantiated. Review of lessons learned from Vault 6B transfer system and outcome of Hinkley Point A Hydrotrans development work. The best technique will then be selected to suit the location of the Wet ILW Facility at BWA. The use of a cross-site bowser system may be investigated dependant on the location of the ILW management facility and the product transfer scheduling.
R&D D	Wet ILW – Blending of sludges and resins. Trials (including batching of discrete quantities of resin) & formulation development. Within the ILW Characterisation project samples of sludge and resin will be taken to undertake bench scale tests to provide initial information on formulations to combine IX resin and sludges in a single compliant Nirex package.	To prove that ILW sludge and resin can be mixed inside the Nirex drum and immobilised together to optimise wet ILW loading in a Nirex compliant wasteform. Initial work required to provide draft substantiation to the technical baseline assumptions.		£100k to £1M	Need		**Bradwell Lead Site** R&D work has been undertaken in this area. However, bench scale trials using samples of active material will be required to confirm formulation envelope. A volumetric batching system is required to ensure correct quantities are batched into the Nirex compliant wasteform. The repeatability and potentially failure modes will need to be developed to gain Nirex acceptance of the process and formulation. Development and trials will be undertaken to identify and deploy suitable blending/mixing equipment within the IX resin settling tank. The on-going use of TILWSP at Trawsfynydd will be reviewed for its suitability for deployment at Bradwell.

Task ID	Technical need - task + gap	Context of why a problem	Target Date	Cost range	Needs / Risks / Opportunity	Site / Generic / NDA issue	Key outputs / Actions
							The Waste Addition & Mixing Head (WAMH) unit will be studied to evaluate the use of a simpler TILWSP arrangement for the treatment of the potentially smaller volumes of wet ILW.
R&D E	Confirmation that the existing Wet ILW material is actually ILW and can be solidified into a Nirex compliant wasteform processed using the dissolution method.	Retrieve representative quantities of active material, to provide samples for physical and radiochemical assay and tests. Provide sufficient samples of material to conduct bench scale tests. The operation of the TRSDU system on Bradwell wastes needs to be demonstrated as providing cost benefits for volume concentration and the subsequent reduction in Nirex package numbers. The installation of the TRSDU at Trawsfynydd will be monitored for lessons learnt.		£100k to £1M	Need		Previous samples have been taken at Bradwell. Specifications for tender for these operations at Bradwell and engagement of a contractor are complete. Dependent on these sampling studies it is likely further sampling and information gathering exercises will be required. The radionuclide data from the samples will be used to calculate dose rates and activities for potential transfer, processing and discharges associated with the dissolution process. This will support submissions for Regulatory acceptance of the process at Bradwell Preliminary shielding calculations will be undertaken to support potential options. The installation and integration of the TRSDU into the Wet ILW processing at Trawsfynydd will be monitored to develop the deployment of the unit at Bradwell.
R&D F	Package Despatch & Cross Site Transport. Selection of system and accuracy/repeatability of alignment for docking operations	The Cross Site Transport system is yet to be specified. This system is integral in the import/export facilities associated with Nirex container handling and immobilisation and the ILW store operation.		£50k to £100k	Need		**Berkeley and Hinkley Point A** are developing designs for this unit. Bradwell will note the outcome of this development and integrate the optimum design into the Bradwell facilities.
R&D G	Facilities Housing – General arrangement of a ‘fit for purpose’ structure to house the Wet ILW processing facilities needs to be developed.	The strategy for the processing of Sludge and IX resins and the package formulation will need to be confirmed to allow provisional shielding calculations to be undertaken. This will indicate the typical internal cell constructions and the general building wall construction. This will then indicate the type of structure that can be utilised. The scope will be potentially reduced if the Wet ILW process facility is combined in the same building as the Solid ILW.		£50k to £100k	Need		Following the production of a typical Process PFD and associated process plant layout, the shielding requirements and the facility to provide this can be developed.
R&D H	Combining of Wet ILW solidification plant and Solid ILW plant in single facility.	The opportunities presented by FED dissolution and reduced volumes of Wet ILW packages, due to conditioning of the IX resins, the potential volumes of Wet and Solid ILW Nirex packages are substantially reduced. The potential to house a Wet ILW WAMH system, within a separate process cell, and a grout head for the Solid ILW in another process cell, but all within the same facility has substantial benefits. The import and export facilities can be common, as well as the lid bolting, swabbing and inspection station. This will also save building 2 buildings		£100k to £1M	Risk & Opportunity		**Bradwell Lead Site** A review of previous development and experimental data is in progress. Discussions have been held with Berkeley and Hunterston to evaluate their individual systems. Logistics and operational throughput models are required to evaluate the proposal. Benefit will be obtained from other sites relevant design work but this will need to adapted/modified to meet the precise requirements for Bradwell’s waste streams and volumes.

Task ID	Technical need - task + gap	Context of why a problem	Target Date	Cost range	Needs / Risks / Opportunity	Site / Generic / NDA issue	Key outputs / Actions
R&D J	FED throughput and processing requirements. Review of FED characterisation studies on process parameters and design solutions.	Current design solutions, including the baseline of encapsulation and the opportunity of Dissolution, are based on theoretical data and limited physical characterisation. On-going vault sampling, characterisation and radionuclide assay will provide accurate design data which may affect the current concept designs.		£100k to £1M	Immediate Need		On completion of the FED vault sampling and analysis, key design studies will be required. Development work will be required to optimise the grout formulation to ensure complete penetration of the wasteform to minimise voidage, based on accurate simulants. The ratio of solid FED and sludge will enable an accurate OR model to be produced for the retrieval operation and the layout of the encapsulation plant (i.e. number of grout heads) or the Dissolution plant (i.e. size of Reaction vessel)
R&D K	Solid ILW Assaying systems	Further R&D is required to correlate sampling & fingerprint data of FED material with respect to filled, un-encapsulated Nirex box contact dose rates. Potential to simplify assaying regime for Nirex compliance and potentially simplify the process and improve throughput rates.		£50k to £100k	Need		**Bradwell Lead Site** Successful systems have been developed for other sites. However, there is the potential to eliminate the need for high-resolution gamma spectroscopy on all materials and develop a regime based upon sampling data and dose measurement. The aim is to improve upon the baseline to simplify the process and reduce costs.
R&D L	Lid Bolting System	To identify, optioneer, and underpin the design of the lid bolting system to establish its suitability for use.		£50k to £100k	Need		**Hinkley Point A Lead Site** Bradwell will review the design progress of other sites and develop a site-specific design for the lid bolting system. In conjunction with the manufacturer, a test rig and mock-up trials will be undertaken.
R&D M	Solid ILW Conditioning	To ensure the FED material is Nirex compliant (no loose contamination), free from sludges prior to the encapsulation process.		£50k to £100k	Need		No system has currently been substantiated to progress cleaning techniques (including sludge collection & transfer systems).
R&D N	Desiccant Storage, Processing & Disposal	There is currently no regulatory agreed and approved disposal route for this material. In addition, cement based formulations potentially generate airborne tritium releases during treatment and storage which may exceed the sites discharge consents. R&D is required in support of BPEO/BPM studies.		£50k to £100k	Need		**Bradwell Lead Site** A current long-term storage option has been identified but a final disposal route is still required. Development work is required to generate a regulatory approved disposal option for all Magnox sites – hence it is expected that this work will be centrally co-ordinated. Dependant on sampling results and radionuclide assay, the potential airborne Tritium release during the curing phase of a cement based immobilisation process will need to be assessed. This data will be required to demonstrate BPM and potential changes to the site discharge authorisation.

Task ID	Technical need - task + gap	Context of why a problem	Target Date	Cost range	Needs / Risks / Opportunity	Site / Generic / NDA issue	Key outputs / Actions
R&D P	MCI & graphite dust management. Disposal of ILW contaminated HEPA filter elements.	The currently identified solution for the management and disposal of these items, is containerisation and deferred encapsulation. Further work is required to underpin and substantiated this assumption and gain regulator approval for the final disposal solution.		£50k to £100k	Need		**Bradwell Lead Site** A BPEO/BPM study is to be undertaken for the storage and final disposal of FED material. If the outcome is not prompt encapsulation, then a small, simple 'fit-for-purpose' encapsulation facility may be required for the final disposal of MCI. Currently, Graphite (reactor core) dust is stored in plastic bags inside heavy wall steel containers. Studies are required to propose and evaluate potential immobilisation techniques, to develop a BPEO/BPM and ALARP solution for the final disposal of the graphite dust. Consideration of work undertaken at BNLS will be reviewed. Similar studies are required to identify and substantiate a Nirex compliant, disposal route for HEPA filter elements and similar items.
R&D Q	Miscellaneous Activated Components (MAC). Provide safety case for continued storage during C&M or processing of MAC arisings during the C&M Prep phase	The strategy is to allow the MAC to remain in-situ in the Reactor Pressure vessel of the Reactor storage tubes / quarter voids. The MAC will then be retrieved and processed at FSC, when it has had the benefit of radioactive decay. (The MAC may well be LLW by this point). A suitable safety case will need to be developed for the continued storage of the MAC until FSC.		£50k to £100k	Need		The design solution for the retrieval, handling and processing of MAC at Berkeley will be monitored and incorporated into the design solution for Bradwell if there are any MAC arisings during the C&M Prep phase. The ongoing central strategy review for the works to be undertaken at FSC and the arrangements for C&M will be incorporated into the arrangements for the safety case and periodic review for the on-going storage of MAC .
R&D R	Containerisation and off-site treatment and storage of MCI	If the opportunities of FED dissolution and gravel treatment are realised, then the only significant Solid ILW waste stream is MCI. The requirement for a Solid ILW management facility could be re-evaluated.		£100k to £1M	Opportunity		The final Solid ILW waste quantities will need defining. Development work will be required to develop a strategy for containerisation of MCI with the regulators. This will then need to address the final solution of immobilisation at final site clearance or immobilisation at another facility and storage. This will be supported by work being undertaken centrally within the Southern bundle on off-site transportation of ILW material.
R&D S	Removal of PWTP and AETP systems	The DV for Pond Decontamination has established the requirement for a Mobile Active Effluent Treatment Plant (MAETP) to enable the station equivalents to be removed during the decommissioning activities.		£100k to £1M	Need		Review of previous and current studies and lessons learned from the specification and procurement of this mobile plant for Hunterston A and Trawsfynydd sites. Development and substantiation of the unit to meet the specific site requirements.

Task ID	Technical need - task + gap	Context of why a problem	Target Date	Cost range	Needs / Risks / Opportunity	Site / Generic / NDA issue	Key outputs / Actions
		If the opportunity for FED volume reduction using the Dissolution process is realised, the plant includes an abatement facility for the discharge liquors (approx. 6 – $12m^3$ per day. This could be used as an alternate AETP.					Evaluation of the benefits of combining the TRSDU facility from the Wet ILW processing unit with a lower specification MAETP to meet the site requirements. Evaluate the potential to use or modify the specification of the Dissolution plant abatement facility in place of a separate MAETP unit.
R&D T	Contained demolition of Contaminated Structures	It is anticipated that not all the contamination will be removed from the Ponds structure prior to demolition. Arrangements need to be developed for controlling the demolition activity and the subsequent large-scale monitoring of the waste activity for consignment of the waste to the correct disposal routes.		£50k to £100k	Need		Techniques for large-scale activity monitoring of the waste to be developed and tested. Guidance documents to be developed to provide best-practise for this operation.
R&D U	Solid and Wet ILW storage facility	The current baseline assumes the prompt encapsulation of FED and packages derived from processing organic IX resins, gravel and MCI. Based on the implementation of the opportunities detailed above, the quantities of Nirex packages may be drastically reduced.		£100k to £1M	Opportunity		If the current proposal for the ILW store is considered unwarranted, then development is required of a concept for an interim store for a much smaller number of packages. It is considered that this building will be a simple, secure storage facility for overpacked packages. The overpacks will be handled within the store using a FLT or similar.
R&D V	On-Site Disposal	An opportunity has been identified to examine the possibility of licensing an area on-site for the storage of Low Active Low Level Waste. This will reduce transport, storage & disposal costs and relieve the burden on current and future LLW repositories. It is assumed that the estimated remaining 10% of more active LLW will still be consigned to a national disposal site.		£100k to £1M	Opportunity		Feasibility work is currently ongoing and is being co-ordinated centrally, including preliminary stakeholder engagement to ascertain the feasibility of these proposals. Works will progress to further substantiate these proposals dependant on initial stakeholder responses.
R&D W	Back to Bioshield approach	To enable early FSC, it is proposed that the Safestore project be amended to consider the feasibility of de-plant, dismantling and demolition in and around the reactor buildings to leave the Bioshield accessible for early FSC.		£100k to £1M	Need		The project will be undertaken with the aim of assessing potential options and substantiating the approach.

Table 2B: Bradwell, Changes from 2007 – 2008 R&D Submission – work completed or deleted.

Task ID	Technical need - task + gap	Target Date	Cost range	Identification of Change	Key outputs / Actions
Radiation Controlled Area (RCA) De-plant and Demolition **Preparation 5.1** **Boilers 5.2**	Bradwell is currently undertaking asbestos stripping from the boiler houses. Waste volume and associated hazards could be reduced with the use of new technologies.	Completed 2007	£50k to £100k	Completed. R&D 30	In conjunction with the Contractor, Health Physics developed a bag monitoring regime, whereby the activities within the asbestos could be averaged (by agreement with the EA). This enabled the majority of the asbestos waste to be consigned to conventional land fill locations (for asbestos) rather than specialists sites dealing with radioactive waste, therefore producing benefits in project cost and schedule.
Ponds Decommission-ing **Fuel Skips and mobile ponds furniture. 3.4**	It has been assumed that the majority of Ponds furniture and skips can be cleaned to LLW or Free release items. This assumption required underpinning and substantiating via field trials.	Completed Dec 2007	£50k to £100k	Completed R&D 25	Through development trials, a method of operation using jet cleaning equipment, has been developed and is in use to decontaminate loose Ponds furniture, skips and inserts to a level whereby the items can be loaded into HHISOs for disposal to the LLW repository of trans-shipped for metal melting processing.
Solid ILW - Retrieval & Processing **Processing requirements 2.3**	The tasks identified in R&D 18 have been progressed up to the Concept design level. Further development is ongoing.	Completed Jan 2008	£100k to £1000k	Partially Completed R&D 18	This activity was covered by the Opportunity for Dissolution Project and the activity for the FED has been developed to the Concept Design is complete, including the BPEO study. Further work is being conducted in 2008 to complete the development of the Concept design and underpin the BPM study. These activities are part of the R&D activity for 2008/2009