

Remediation of the Legacy Ponds & Legacy Silos

Baseline Best Practicable Environmental Option Study

Stakeholder Consultation Briefing Note

1. Introduction

This briefing note has been prepared to provide background for a workshop on the stakeholder consultation on the Baseline Best Practicable Environmental Option (BPEO) study for the remediation of the Legacy Ponds and Legacy Silos (LP & LS). It is structured around a number of key questions where British Nuclear Group Sellafield Ltd (BNGSL) would welcome the views of stakeholders.

As part of the clean-up of the Sellafield site and in preparation for decommissioning, BNGSL intends to remediate the LP & LS facilities so that they are in a state that is safer and more environmentally acceptable. The LP & LS remediation plans are currently progressing through the early stages of the design process and a Baseline BPEO study is required to provide guidance for selecting waste retrieval, treatment, storage and effluent management options.

The concept of BPEO has gained widespread acceptance in the United Kingdom as a result of the work of the Royal Commission on Environmental Pollution, who provided the following definition of BPEO in its Twelfth Report (1988):

“.....the outcome of a systematic and consultative decision making procedure which emphasises the protection and conservation of the environment across land, air and water. The BPEO procedure establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as the short term.”

The interpretation of BPEO in the context of radioactive waste management has traditionally been taken to involve wide-ranging strategic exploration of the balance between environmental impact, health and safety, technical feasibility and cost. Guidance from the Royal Commission and the Environment Agencies indicates that stakeholder consultation should be integral to the assessment of options.

BNGSL's own consultation guidance emphasises the importance of dialogue with stakeholders, including members of the public, to ensure that the technical assessment of options considers alternative values and opinions. For the LP & LS Baseline BPEO study, stakeholder dialogue will be achieved through direct interaction with stakeholders in a workshop and publication of consultation documents on the internet to invite wider feedback.

2. Legacy Ponds & Legacy Silos Facilities

Early nuclear fuel reprocessing operations used the Sellafield LP & LS facilities to store fuel prior to reprocessing and to hold the fuel cladding that was separated from the fuel during the preparation of the fuel for reprocessing. The facilities contain wastes that have accumulated over a period of around 50 years – hence “legacy” wastes.

BNGSL has recognised that whilst the legacy wastes in LP & LS are managed in a safe manner today, they cannot continue to be retained in their current facilities. The need to take appropriate action to safely manage the legacy wastes in the ponds and silos in a safe and environmentally responsible manner is the basis of LP & LS remediation. LP & LS remediation aims to retrieve and make the legacy wastes safe for long-term storage and eventual disposal. This will leave the LP & LS facilities in a condition that will be suitable for subsequent final decommissioning. Both LP & LS remediation and final decommissioning will be funded by the Nuclear Decommissioning Authority (NDA) and will need to consider the proposed endpoint of the Sellafield site.

Recovery and treatment of the stored wastes presents significant technical challenges. The inventory and range of radionuclides in these legacy wastes is extensive. The range alone poses difficult challenges for waste retrieval and processing. Some wastes, such as aluminium and Magnox fuel cladding, have degraded, resulting in the presence of corrosion products and the redistribution of radioactivity in the storage facilities.

As Sellafield site operations and experience developed, increasing segregation of waste types occurred prior to and during storage. Hence, the stored wastes range from relatively unsegregated to highly segregated material. Record keeping, although adequate for the expected standard at the time of emplacement, was less robust than modern expectations and so there are gaps in our knowledge of the detailed inventory.

The earliest of the LP & LS facilities was commissioned in the 1950s. Since then, the nationally expected standards for ‘new build’ facilities have increased considerably, particularly in the areas of safety and environmental performance. Where technically and financially feasible, the LP & LS waste storage facilities have been modified to reduce risk. Providing an acceptable balance between modern expectations and the practical difficulties posed by the stored wastes presents a significant challenge to recovering and rendering them safe for long-term storage and eventual disposal.

The legacy wastes constitute a major element of the radioactive waste inventory at Sellafield. The majority of the intermediate-level waste (ILW) that is in the form of “sludge” on site is in the LP & LS facilities. Consequently, the wastes located in the LP & LS facilities represent some of the most challenging nuclear clean-up issues in the United Kingdom.

The legacy wastes in the Sellafield LP & LS are principally contained in the following facilities:

- The Pile Fuel Storage Pond
- The Magnox Fuel Storage Pond
- The Magnox Cladding Wet Storage Silos
- The Dry Storage Silos.

Pile Fuel Storage Pond

The Pile Fuel Storage Pond is an open storage pond built between 1948 and 1952 for underwater storage of radioactive fuel from the Windscale Pile reactors. Operations in the pond included the receipt, storage and removal of the outer casing (known as decanning) from fuel elements from the Windscale Pile reactors and other UK reactors, such as those at the Calder Hall and Chapelcross power stations. The decanning operations produced broken pieces of the fuel outer casing known as swarf.

By 1962, the pond was being used as an *ad hoc* waste storage facility, with operations ceasing in the early 1970s. The pond has since remained out of use, but under a programme of surveillance and maintenance with extensive refurbishment taking place during the 1980s and 1990s.

The material in the pond comprises sludge that has resulted from the corrosion of swarf within the pond, and small quantities of fuel and miscellaneous technological waste such as redundant equipment that has become radioactive during its lifetime. This latter component is more commonly known as Miscellaneous Beta Gamma Waste (MBGW). However, it should be noted that the Pile Fuel Storage Pond sludge differs from other LP & LS sludge in that it is not principally derived from the corrosion of fuel, and contains a significant proportion of biologically derived material such as guano, algae and wind-blown debris. Analysis of sludge samples indicates that it generally contains a lower radionuclide content than other LP & LS sludge.

Magnox Fuel Storage Pond

The Magnox Fuel Storage Pond was built to store Magnox fuel prior to reprocessing. The pond operated from 1959 to 1985. Prior to reprocessing, the Magnox fuel was decanned in the pond. Much of the decanning equipment remains in the pond.

The material in the pond comprises sludge that has resulted from the corrosion of swarf within the pond, and quantities of fuel and MBGW.

In 1985 a new radioactive liquid effluent treatment facility became operational. A substantial amount of sludge has now been transferred from the pond into storage tanks in the effluent treatment facility.

Magnox Cladding Wet Storage Silo

The Magnox Cladding Wet Storage Silo comprises four adjacent concrete silos, each of which is divided into several compartments. These were built over a number of years, with the original silo entering service in 1964 and three subsequent silos becoming operational in 1972, 1981 and 1983.

The silo was primarily used for the underwater storage of Magnox cladding swarf resulting from the removal of the outer casing from fuel prior to reprocessing. Waste emplacement in the silo ceased in 2000. The material in the silo comprises sludge, and small quantities of MBGW and fuel.

Some waste has already been retrieved from the more recently constructed compartments, packaged in a form suitable for extended storage and disposal and is now in temporary storage on site. This was achievable because the physical condition of this portion of the waste was compatible with existing waste processing plants. The physical condition of the remaining waste is not.

Dry Storage Silo

The Dry Storage Silo was designed for dry storage of swarf resulting from the removal of the outer casing from fuel used in the Windscale Piles prior to reprocessing. The silo was operational from 1952 to 1964.

The material in the silo is principally aluminium swarf, fuel from the Windscale Piles, Magnox swarf from civil nuclear reactors, graphite, and other MBGW.

3. Objective of the Baseline BPEO Study

The objective of the LP & LS Baseline BPEO study is to form guiding views and statements that need to be considered when undertaking lower level, more detailed BPEO studies for waste retrieval, treatment, storage and effluent management options. As part of this study, BNGSL is seeking feedback from stakeholders.

Because of the complexities and implications of the issues that need to be considered, the goal of this consultation is not to reach a consensus or clear choice on remediation options, but to collect feedback that will allow the formation of strategic recommendations that govern the remediation programme. These recommendations will be made in consideration of larger BNGSL and UK strategies that take into account socio-economic impacts and other relevant factors and will govern the subsequent selection of waste retrieval, treatment, storage and effluent management options.

The ultimate vision for the Sellafield site restoration strategy is to make the land occupied by the LP & LS facilities available for other possible future uses consistent with the proposed endpoint of the Sellafield site. It includes actions taken to systematically and progressively reduce hazard levels. This is not a single-stage process and will involve many stages spread over a number of years. There are three essential stages – remediation, decommissioning and demolition:

Remediation Remediation is the set of actions necessary to prepare the LP & LS facilities for decommissioning. Remediation has several major component parts, as described in the following table.

Remediation Component	Description
Waste Retrieval	The management of the LP & LS facilities prior to and during the retrieval of waste.
Waste Storage	Storage of retrieved material in modern standard facilities prior to treatment. (Note for clarification: For this particular study, consideration of storage is limited to storage prior to treatment. Storage of treated packaged waste is considered as part of the wider Sellafield strategy.)
Waste Treatment	The processing of retrieved material into a form suitable for temporary on-site storage and disposal in a final repository, thus reducing the hazard associated with the material (it is assumed that a repository would not be available prior to 2040).
Effluent Management	The management of aerial and liquid effluents resulting from remediation so that they can be safely discharged with the minimum environmental detriment. This necessarily includes consideration of waste avoidance, recycle and re-use, with discharge as the least preferred choice. At this stage of remediation, the focus is primarily on radioactive effluents. As plans and plant designs mature, the focus will include non-radioactive effluents.

Decommissioning Decommissioning typically involves removal of plant and equipment and, wherever possible, a reduction in the facility footprint. Facilities that have been decommissioned will be out of service with adequate regard for the health and safety of workers and the public and the protection of the environment.

Demolition Demolition will remove the out-of-service facilities and allow the site to be redeveloped for alternative uses consistent with the proposed endpoint of the Sellafield site.

The LP & LS activities focus upon remediation. Decommissioning and eventual demolition will be addressed as part of the wider Sellafield site activities.

Remediation is a major step along the path to decommissioning. It will essentially result in the removal from the LP & LS facilities of bulk waste and liquor. Radioactive material adhering to walls of the facilities will either be removed or fixed to a point where forced ventilation systems are not necessarily required. This endpoint will conform to the current Sellafield Site Licence Conditions and, in particular, those that pertain to the control and containment of radioactive material and radioactive waste.

Question 1 Do you have any comments on the overall objective for the remediation of the Legacy Ponds and Legacy Silos facilities and the objective of this Baseline BPEO study?

4. Approach to the Stakeholder Engagement Including the BPEO Study

BNGSL is pursuing stakeholder engagement at four levels:

- The uppermost level, aimed at selecting the national strategy, is led by the NDA and will involve engagement with a very broad range of stakeholders including the European Community.
- The second level, aimed at selecting site strategies, is working under the framework set by the first level and is led by BNGSL. This also involves engagement with a very broad range of stakeholders, although not as broad as the uppermost engagement level.
- The third level, aimed at developing guiding statements for specific components of the site remediation strategy, is led by BNGSL and involves engagement with a range of stakeholders comprising the local community, the regulators and internal BNGSL stakeholders.
- The fourth level, working under the framework set by the third level and aimed at selecting project options, is led by BNGSL and involves engagement with a narrower range of stakeholders comprising the regulators and internal BNGSL stakeholders. This level generally does not involve the public but may do so, for example if there is a potential direct impact such as large increases in road traffic.

The overall approach to stakeholder engagement described above has been discussed with the NDA, the regulators and internal BNGSL stakeholders.

This LP & LS BPEO study, which is at the third level described above, is examining the remediation of the LP & LS facilities and is principally focused on four component parts: waste retrieval, storage, treatment, and effluent management.

Each of these areas has been examined and several issues that may be of interest to stakeholders have been identified; feedback on these issues is sought. The issues are to be reviewed with respect to their health & safety, environmental impact, technical feasibility and cost implications.

The issues addressed are purposefully high level and the feedback will provide guidance and a framework for more specific BPEO studies that focus on project options with a narrower range of stakeholder involvement. The feedback will be used by projects, as a component of the fourth level of stakeholder engagement described above, to shape and balance the more detailed BPEO studies. The more detailed BPEO studies will consider technology choices and ultimately select the options that will be progressed. The feedback from the Baseline BPEO study will therefore directly influence option selection and the investment in the LP & LS facilities.

Question 2	Do you have any comments on the general approach to stakeholder involvement in the Legacy Ponds & Legacy Silos Baseline BPEO study? Do you understand how your feedback will be used to inform programme recommendations for consideration under the Sellafield and NDA strategy?
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5. Minimum Requirements

There are some minimum requirements that must be achieved by whatever processes are chosen to remediate the LP & LS facilities. These minimum requirements can be used to “screen” options and identify those options that cannot be taken forward for detailed assessment. The following are the minimum requirements adopted for the LP & LS Baseline BPEO study:

- Regulatory standards for worker and public safety must be met.
- Technology must not be infeasible, that is, techniques should be known and either available or being researched and developed to such an extent that they can be expected with confidence to be available within the appropriate period.

It is not the intention to preclude the consideration of options that, although they appear unlikely, are nevertheless feasible. For example, options must ideally conform to UK law and be consistent with international conventions and agreements such as OSPAR (the Oslo/Paris Convention for the Protection of the Marine Environment of the North-East Atlantic), but options that do not could still be considered.

6. Regulatory Standards and Legal Requirements

6.1 Nuclear Installations Inspectorate

In 1999, the Nuclear Installations Inspectorate (NII) published the findings of a review into ILW storage in the UK. The conclusions of relevance to LP & LS are that:

“(i) There is a considerable legacy of ILW from the past: substantial amounts are in a raw form and potentially mobile.

(ii) [The NII] would like to see a move away from the storage of potentially mobile waste towards conditioning radioactive waste for passive storage.

(iii) Some of the older facilities at Sellafield are in poor structural condition and not fitted to their purpose for the long term storage of ILW.”

In 2000, the NII formalised their position on Sellafield via a series of License Instruments that specified the timescale for improving arrangements for ILW storage at Sellafield. The most important of these are:

”(a) At least 90% of the total volume of potentially mobile Intermediate Level Waste which has been accumulated as sludge in the Pile Fuel Storage Pond shall be stored as a sludge/slurry form within modern stainless steel containment by 1 August 2009.

”(b) At least 90% of the total volume of potentially mobile Intermediate Level Waste which has been accumulated as sludge in the Magnox Fuel Storage Pond shall be stored as a sludge/slurry form within modern stainless steel containment by 1 August 2010.

”(c) At least 80% of the total volume of all Intermediate Level Waste sludges originating from operations prior to 1 August 2000 and which have been accumulated as radioactive waste shall be stored in a safe passive form by 1 August 2020.

”(d) The contents of the Dry Storage Silo which have been accumulated as radioactive wastes shall be stored in a place and manner approved by the NII by 1 August 2016.”

The ownership of the Sellafield site transferred to the NDA in early 2005, with BNGSL operating the site on behalf of the NDA. The Licence Instruments remain the basis for BNGSL's future plans.

6.2 Environment Agency

The Environment Agency has recently reviewed the authorisation for the disposal of radioactive wastes from the Sellafield site granted under the Radioactive Substances Act 1993. Following engagement with stakeholders in the UK and overseas, a new authorisation has been produced for regulating radioactive waste disposals to the environment. The authorisation provides discharge limits and conditions that provide an environmental framework in which LP & LS remediation must be conducted.

Some of the key aspects of the new authorisation that guide the LP & LS work are:

- A reduction in public dose uptake through reductions in aerial discharge limits and liquid discharge limits.
- No increases of discharge limits above previous levels.
- New conditions that include:
 - Control of discharges from individual plants as well as the site as a whole;
 - Strengthening the existing concept of Best Practicable Means;

- A requirement to have management systems, organisational structures and resources to achieve compliance;
- A significant programme of environmental improvements; and
- A requirement to demonstrate that current disposal routes for all radioactive wastes represents the BPEO.

Question 3 Do you have an appreciation of the constraints and legal requirements applied in screening options for the remediation of the Legacy Ponds & Legacy Silos facilities?

7. Overview of Issues of Concern

BNGSL has already expended considerable effort over many years examining potential remediation options. This has resulted in the accumulation of a good knowledge base, but nevertheless, there are several potentially controversial issues, the resolution of which could shape the future approach. The issues are interdependent and, therefore, potential solutions to an individual issue should not be considered independently of potential solutions to other issues.

The issues are described in more detail below:

Issue 1

Any form of intervention to remediate the LP & LS facilities will potentially increase radiation exposure to workers or increase radioactive releases to the environment in the short term. The LP & LS facilities require careful monitoring and continued investment to maintain them in an adequate condition and thus minimise the potential for radiation exposure or radiation releases. The necessary resource expenditure reduces that available to provide retrieval and treatment facilities. The issue of concern is:

- *What is the BPEO for managing risks prior to removal of waste from the LP & LS facilities? Should retrievals from the LP & LS facilities be delayed whilst further engineered protective measures are installed or should retrieval be accelerated without any further measures installed?*

Issue 2

In order to meet the timescale for the Licence Instruments, it may be necessary to construct storage for raw waste or to minimally process waste whilst treatment facilities are constructed. This essentially creates new liabilities that will themselves eventually require remediation, decommissioning and eventual demolition. The issue of concern is:

- *What is the BPEO for allowing timely construction of waste treatment facilities? Should retrieved material be stored whilst final treatment facilities are constructed or should retrieval be delayed until they are available?*

Issue 3

There are safety and environmental drivers for processing waste into packages that are suitable for direct disposal in a repository without requiring re-work. Nirex is charged with developing and advising on options for the long-term management of radioactive materials, and already has available a repository concept and packaging specifications that cover the LP & LS wastes. However, for some legacy wastes, their nature and the knowledge gaps in the detailed inventory provides significant challenges to meeting the Nirex packaging specifications. In order to avoid excluding options for the design of the repository, it is therefore necessary to design waste packages now that are robust against reasonably foreseeable eventualities. This requires that the knowledge gaps referred to are closed sufficiently to provide an understanding of how the waste package might perform in the long term. The pursuit of this knowledge is ongoing, but it may take a considerable time to obtain. This, in turn, may impact on the precise time that waste packaging, and hence hazard reduction, can commence.

In order to reduce the hazard presented by the legacy wastes in a more timely way, the possibility of initially packaging waste into a basically stabilised form that might not meet the Nirex packaging specification and to subsequently re-work these into a final disposal package needs to be considered. In this context, it is reasonably assumed that any re-work of a package will only need to be carried out immediately prior to final disposal and not at any interim stages. A logical extension of this approach is to also consider minimally processed packages where this may give significant benefits in terms of more rapid risk reduction. These approaches would have attendant safety and radioactive discharge implications.

The issue of concern is:

- *What is the BPEO for the waste package form? Should the legacy wastes be processed into products that (a) meet the Nirex packaging specification for direct disposal to a repository or (b) are basically stabilised or (c) are minimally processed where basically stabilised or minimally processed products would require re-work to make them disposable to a repository?*

Issue 4

It is not intended that effluents will be unnecessarily created and, that where this is necessary, then a waste management hierarchy of avoid, minimise, re-use, re-cycle and lastly abate will be adopted. However, it is anticipated that even with these approaches, remediating the LP & LS facilities will inevitably produce liquid and aerial effluents that require discharge.

The Sellafield site has a discharge authorisation that includes limits for particular radionuclides in solid, liquid and gaseous form. National and international policy is that radioactive discharges will be progressively reduced. In order to adhere to existing discharge limits and to conform to international agreements to progressively reduce discharges, it will be necessary to either upgrade existing effluent treatment facilities, construct new ones, or adopt an approach that combines these aspects. It is considered undesirable for retrieval and treatment operations to commence in earnest without upgraded or new facilities being available. As a worst case, this might require that waste retrieval and treatment are delayed, thereby jeopardising the NII License Instrument dates for waste retrievals.

An alternative approach that might allow earlier commencement of waste retrieval and treatment and considerably reduce the requirement for new investment in effluent treatment facilities could be the use of “management tools”. These tools include:

- Adapt the rate of treatment of legacy wastes so that the resultant radioactive discharges remain within the currently allowable levels.
- Closure of other effluent-producing processes on site to create additional headroom in the currently allowable discharges that could be used to allow an increased rate of treatment of the legacy wastes, and hence a more rapid hazard reduction.
- Increased radioactive discharges from the Sellafield site (possibly above the currently allowable levels), thereby allowing the maximum rate of treatment of legacy wastes and hence the maximum rate of hazard reduction.

The issue of concern is:

- *What is the BPEO for managing the LP & LS effluent streams? Is use of management tools, engineering tools or a combination of management and engineering tools preferred?*

Some of the above concerns can be addressed for both the ponds and silos in tandem; other issues may have unique considerations that need to be discussed separately.

Question 4	Do you have any comments on the issues on which feedback is sought? Have any issues been overlooked?
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8. Review Criteria

The comparison of options must use a consistent set of criteria. For this BPEO study, the criteria are under four main evaluation categories: health & safety; environmental impact; technical feasibility; and cost. Socio-economic impacts have not been considered in detail as they are the remit of the larger Sellafield site and NDA engagements; however, we have noted where there is an obvious issue associated with potential socio-economic impacts.

Under the four evaluation categories, BNGSL has developed a preliminary list of comparison attributes believed to be of primary importance. This preliminary list has provided a basis for immediate progress, but nevertheless represents BNGSL's own view and therefore requires confirmation via this engagement. This preliminary list was targeted on those attributes that BNGSL consider may be a differentiator regarding the questions at hand. For example, if there was no noise or traffic impact beyond the site boundaries, this was not identified as a criterion.

Below is a table describing the various attributes:

Evaluation Attribute Group	Attribute	Sub-Attribute
Health & Safety	Risk to Workers and the Public	
	Hazard to Workers and the Public	
Environmental Impact	Waste Volumes	ILW Volumes
		Other Waste Volumes
	Effluent Impacts	Liquid
		Aerial
Technical Feasibility	Viability	Maturity of Technology
		Process Complexity
	Flexibility	Re-workability of Product
	Alignment with Discharge Authorisation	
Conformance with Licence Dates		
Cost	Cost	

Question 5	Do you agree that the list of attributes is reasonable? Which attributes are of greatest importance? Have any attributes been omitted that are of particular concern?
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9. Options Review

Issue 1: What is the BPEO for managing risks prior to removal of waste from the LP & LS facilities? Should retrievals from the LP & LS facilities be delayed whilst further engineered protective measures are installed or should retrieval be accelerated without any further measures installed?

Any form of intervention to remediate the LP & LS facilities will potentially increase radiation exposure to workers or increase radioactive releases to the environment. These aspects need to be considered carefully in any remediation plans.

Ponds

The ponds are constructed of concrete, but are without a protective cover. This results in the potential for unauthorised emissions from the two pond facilities. Unauthorised emissions include radioactive aerosol from the surface of the water which workers may be exposed to, seepage of radioactivity into the ground, and radioactive contamination that becomes attached to birds that settle on the pond surface and that is then carried to other places.

Whilst the remediation of already contaminated ground is part of the wider Sellafield site strategy, the remediation of the LP & LS facilities nevertheless has to consider how any increased burden on already contaminated land will be prevented or minimised. The current dose from the ponds is below the allowable limits.

Potential options for managing unauthorised emissions include:

Option	Example	Preliminary Assessment	
Do Nothing		Cost	None
		Advantages	<ol style="list-style-type: none"> 1. Cost savings 2. No schedule constraints 3. More rapid risk reduction 4. Reduces the time that facilities remain a security threat
		Disadvantages	<ol style="list-style-type: none"> 1. Does not reduce unauthorised emissions 2. May contaminate previously uncontaminated facilities thus increasing regulated waste disposal volumes 3. Wildlife dose uptake
		Other Considerations	<ol style="list-style-type: none"> 1. Meets current discharge limits 2. Disturbance during retrievals will elevate discharges
Cover Pond	Overbuilding	Cost	£10M - £100M
		Advantages	<ol style="list-style-type: none"> 1. Reduces unauthorised emissions
		Disadvantages	<ol style="list-style-type: none"> 1. Produces additional secondary waste 2. Unlikely to be achieved in less than five years, hence prolongs presence of risk 3. Prolongs the time that facilities remain a security threat

Option	Example	Preliminary Assessment	
	Rigid floating cover	Other Considerations	1. Level of reduction not known at this time 2. Might have beneficial socio-economic impacts
		Cost	£1M - £10M
		Advantages	1. Reduces unauthorised emissions
		Disadvantages	1. Produces additional secondary waste 2. Prolongs presence of risk 3. Prolongs the time that facilities remain a security threat
		Other Considerations	1. Level of reduction not known at this time
Control Barriers	Wind Breaks	Cost	£1M - £10M
		Advantages	1. Reduces unauthorised emissions
		Disadvantages	1. Produces additional secondary waste 2. Unlikely to be achieved in less than five years, hence prolongs presence of risk 3. Prolongs the time that facilities remain a security threat
		Other Considerations	1. Level of reduction not known at this time
	Floating balls	Cost	~£1M
		Advantages	1. Reduces unauthorised emissions
		Disadvantages	1. Produces additional secondary waste 2. Unlikely to be achieved in less than two years, hence prolongs presence of risk 3. Prolongs the time that facilities remain a security threat
		Other Considerations	1. Level of reduction not known at this time
Ground Leakage Protection	Subterranean barrier, In-ground grouting, ground freezing	Cost	All £10M - £100M
		Advantages	1. Provides good leakage protection
		Disadvantages	1. Generates large volume of secondary waste that requires disposal 2. Could adversely influence local geological conditions and thus the stability of the facility
		Other Considerations	1. Unlikely to be practical around the existing facilities 2. Might have beneficial socio-economic impacts

Note that these options are not mutually exclusive and that the eventual strategy could include several of these options being taken forward.

Silos

The silos are enclosed buildings. One of the silos is a dry storage silo from which there are no recorded instances of leakage to ground. The wet storage silo has had recorded ground leakage. Extensive analysis has attributed the leakage to the original

silos that entered service in 1964. The wet storage silo already has arrangements to monitor the extent of ground leakage. However, monitoring over a considerable number of years indicates that the wet storage silo is currently leak tight. The approach for retrieval from the wet storage silo considers leak tightness by accounting for its integrity and considering appropriate operating methods or engineered provisions. This work, currently in progress, is at a preliminary stage. Options have not yet been identified and this is therefore the optimum time to consider stakeholder feedback.

Both of the silos have installed ventilation systems designed to abate aerial discharges. There is generally additional headroom between the current demand on the ventilation system and its actual capability.

Potential options for managing aerial discharges during retrieval from the silos include:

Option	Example	Preliminary Assessment	
Do Nothing		Cost	None
		Advantages	1. Cost savings 2. No schedule constraints 3. More rapid risk reduction
		Disadvantages	1. May not be able to meet any future reductions in discharge limits
		Other Considerations	1. Meets current discharge limits 2. Disturbance during retrievals will elevate discharges
Upgrade Existing Ventilation System	1. Additional filters 2. Gas scrubbers	Cost	All £1M - £10M
		Advantages	1. Robust technology 2. Able to respond to reduced discharge limits
		Disadvantages	1. May not be able to meet any future reductions in discharge limits
		Other Considerations	1. Meets current discharge limits 2. Disturbance during retrievals will elevate discharges

Question 6 Issue 1: What is the BPEO for managing risks prior to removal of waste from the LP & LS facilities? Should retrievals from the LP & LS facilities be delayed whilst further engineered protective measures are installed or should retrieval be accelerated without any further measures installed? Have we overlooked any options?

Issue 2: What is the BPEO for allowing timely construction of waste treatment facilities? Should retrieved material be stored whilst treatment facilities are constructed or should retrieval be delayed until they are available?

In order to meet legal requirements, it might be necessary to construct facilities to store raw or minimally processed waste whilst treatment facilities are constructed. This approach will create additional liabilities which, in turn, will require remediation, decommissioning and eventual demolition.

Possible options are:

Option	Example	Preliminary Assessment	
Do Nothing		Cost	None
		Advantages	1. Cost savings 2. Additional liabilities not created
		Disadvantages	1. Waste retained in ageing facilities for longer period 2. Prolongs the time that facilities remain a security threat
		Other Considerations	
Provide Interim Storage	Buffer storage tanks	Cost	£10M - £100M
		Advantages	1. Allows more rapid risk reduction 2. Allows opportunity to gather waste characterisation data 3. Reduces the time that facilities remain a security threat
		Disadvantages	1. Creates additional liabilities that require remediation, decommissioning and demolition 2. Uses funding that could otherwise be spent on providing treatment facilities
		Other Considerations	1. Might have beneficial socio-economic impacts

Question 7 Issue 2: What is the BPEO for allowing timely construction of waste treatment facilities? Should retrieved material be stored whilst treatment facilities are constructed or should retrieval be delayed until they are available? Have we overlooked any options?

Issue 3: What is the BPEO for the waste package form? Should the legacy wastes be processed into products that (a) meet the Nirex packaging specification for direct disposable to a repository) or (b) are basically stabilised or (c) are minimally processed, where basically stabilised or minimally processed products would require re-work to make them disposable to a repository?

The primary intent is to package waste in a form suitable for extended storage and disposal in a future national repository. A repository is unlikely to be available before 2040. Nirex is charged with developing and advising on repository concepts, and already has available concept designs and packaging specifications. However, for some legacy wastes, their nature and the knowledge gaps in the detailed inventory provides significant challenges to meeting the Nirex packaging specifications. In

order to avoid excluding options for the design of the repository, it is therefore necessary to design waste packages now that are robust against reasonably foreseeable eventualities. This requires that the knowledge gaps referred to are closed sufficiently to provide an understanding of how the waste package might perform in the long term. The pursuit of this knowledge is ongoing but it may take a considerable time to obtain. This, in turn, may impact on the precise time that waste packaging, and hence hazard reduction, can commence.

In order to reduce the hazard presented by the legacy wastes in a more timely way, the possibility of initially packaging waste into a basically stabilised form that might not meet the Nirex packaging specification and to subsequently re-work these into a final disposal package needs to be considered. In this context, it is reasonably assumed that any re-work of a package will only need to be carried out immediately prior to final disposal and not at any interim stages. A logical extension of this approach is to also consider minimally processed packages where this may give significant benefits in terms of more rapid risk reduction. These approaches would have attendant safety and radioactive discharge implications.

As outlined above, BNGSL's primary intent is to package waste in a form that meets the Nirex packaging specification and hence is suitable for extended storage and disposal in a national repository. However, in instances where this is not possible, it is BNGSL's intent to package waste initially into a form that does not meet the Nirex packaging specification, and to have plans to subsequently re-work the package into a final disposal package. The stakeholder feedback sought will influence the acceptability of this approach.

Potential options are:

Option	Example	Preliminary Assessment	
Nirex Specification Product	Waste that has been segregated into chemically and physically different parts with each part then treated to render it completely safe and then packaged in a way such that the package performance is supplied by the treatment of waste with further protection provided by the package and the repository/storage environment	Cost	
		Advantages	<ol style="list-style-type: none"> 1. Re-work unnecessary for reasonably foreseeable eventualities, hence no secondary waste produced 2. Passively safe package 3. Likely to produce a sustainable package that ideally requires nil or probably minimal management to safely protect people and the environment
		Disadvantages	<ol style="list-style-type: none"> 1. Package specification agreement may take some time 2. Unable to design some treatment plants until proposals agreed, hence might be unable to meet NII Licence conditions 3. Risk and hazard reduction delayed 4. Prolongs the time that facilities remain a security threat
Other Considerations	<ol style="list-style-type: none"> 1. Technology to meet package specification might require further development prior to implementation 2. Packages will require management until the repository becomes available 		

Option	Example	Preliminary Assessment	
Basically Stabilised Product	Waste that has been treated and packaged in a way that renders it safe for a considerable period and where the package performance is supplied mainly by the package and the repository/storage environment	Cost	
		Advantages	<ol style="list-style-type: none"> 1. Suitable technologies may currently be available, hence treatment plant construction can commence 2. Allows earlier risk and hazard reduction 3. Reduces the time that facilities remain a security threat
		Disadvantages	<ol style="list-style-type: none"> 1. Re-work requirements not known, but it is anticipated that re-work will be required and hence it is also anticipated that secondary wastes will be produced, that discharges will be greater, and that collective worker doses will be greater
		Other Considerations	<ol style="list-style-type: none"> 1. Packages will require management until the repository becomes available
Minimally Processed Product	Waste that has undergone minimal processing and has been packaged in a way where the performance is supplied solely by the package and the storage environment	Cost	
		Advantages	<ol style="list-style-type: none"> 1. Technologies are currently available, hence treatment plant construction can commence 2. Much earlier risk and hazard reduction 3. Reduces the time that facilities remain a security threat
		Disadvantages	<ol style="list-style-type: none"> 1. Re-work will be required hence secondary waste will be produced, that discharges will be greater, and that collective worker doses will be greater 2. Packages will require management, possibly to a significant level, until they are re-worked when the repository becomes available
		Other Considerations	

Question 8 Issue 3: What is the BPEO for the waste package form? Should the legacy wastes be processed into products that (a) meet the Nirex packaging specification for direct disposal to a repository or (b) are basically stabilised or (c) are minimally processed, where basically stabilised or minimally processed products would require re-work to make them disposable to a repository? Have we overlooked any options?

Issue 4: What is the BPEO for managing the LP & LS effluent streams? Is use of management tools, engineering tools or a combination of management and engineering tools preferred?

Effluents will not be unnecessarily created and, where effluents must be created, a waste management hierarchy of avoid, minimise, re-use, re-cycle and lastly abate will be adopted. However, it is anticipated that even with these approaches, remediating the LP & LS facilities will inevitably produce liquid and aerial effluents that require discharge.

The Sellafield site has a discharge authorisation that includes limits for particular radionuclides in solid, liquid and gaseous form. National and international policy is that radioactive discharges will be progressively reduced.

The discharges produced by remediating the LP & LS facilities will, if unabated, exceed some of the current discharge limits. However, the cost and programme to provide effluent treatment plants will constrain commencement of retrieval and hence could adversely delay hazard reduction.

Several approaches are possible. Examples include:

- Reliance on administrative controls such as:
 - Adapt the rate of treatment of legacy wastes so that the resultant radioactive discharges remain within the currently allowable levels.
 - Closure of other effluent-producing processes on site to create additional headroom in the currently allowable discharges that could be used to allow an increased rate of treatment of the legacy wastes, and hence a more rapid hazard reduction.
 - Increased radioactive discharges from the Sellafield site (possibly above the currently allowable levels), thereby allowing the maximum rate of treatment of legacy wastes and hence the maximum rate of hazard reduction.
- Reliance on engineered controls such as:
 - Upgrade of current centralised treatment facilities.
 - Construction of new centralised treatment facilities.
 - Construction of new facilities in the locality of the effluent creation.

These examples are assessed in the following table.

Option	Example	Preliminary Assessment	
Administrative Controls	Adapt the rate of treatment of legacy wastes so that the resultant radioactive discharges remain within the currently allowable levels	Cost	Indicative cost £80M – £300M Requires a minimal number of local effluent treatment plants and improvements to the existing effluent treatment processes
		Advantages	1. Allows earlier risk and hazard reduction as there is no need to wait until effluent treatment facilities are constructed 2. Minimal secondary waste production 3. Does not breach current discharge limits
		Disadvantages	1. Timescale uncertain, but unlikely to meet the NII License requirements 2. Likely to prolong the time that facilities remain a security threat
		Other Considerations	
	Closure of other effluent-producing processes on site to create additional headroom in the currently allowable discharges that could be used to allow an increased rate of treatment of the legacy wastes, and hence a more rapid hazard reduction	Cost	No indicative costs available, but requires a minimal number of local effluent treatment plants and improvements to the existing effluent treatment processes that alone have an indicative cost of £80M – £300M
		Advantages	1. Allows earlier risk and hazard reduction as there is no need to wait until effluent treatment facilities are constructed 2. Minimal secondary waste production 3. Does not breach current discharge limits 4. Significant contributor to meeting the NII License requirements 5. Reduces the time that facilities remain a security threat
		Disadvantages	1. May delay other important remediation and decommissioning work on site
		Other Considerations	1. Might have significant adverse socio-economic impacts
	Increased radioactive discharges from the Sellafield site (possibly above the currently allowable levels), thereby allowing the maximum rate of treatment of legacy wastes and hence the maximum rate	Cost	Indicative cost £80M – £300M Requires a minimal number of local effluent treatment plants and improvements to the existing effluent treatment processes
		Advantages	1. Allows earlier risk and hazard reduction as there is no need to wait until effluent treatment facilities are constructed 2. Minimal secondary waste production 3. Significant contributor to meeting the NII License requirements 4. Reduces the time that facilities remain a security threat
		Disadvantages	1. Increasing discharge limits does not accord with national and international policy

Option	Example	Preliminary Assessment	
	of hazard reduction	Other Considerations	
Engineering Controls	1. New local effluent treatment plants	Cost	1. New local effluent treatment plants - indicative cost £250M – £600M 2. Upgrade of existing centralised effluent treatment facilities - indicative cost £100M – £400M 3. New centralised effluent treatment facilities - indicative cost £600M – £950M
	2. Upgrade of existing centralised effluent treatment facilities	Advantages	1. Would ensure that discharge limits are not breached 2. Accords with national and international policy
	3. New centralised effluent treatment facilities	Disadvantages	1. Risk and hazard reduction delayed whilst effluent treatment facilities are constructed 2. Secondary wastes will be produced 3. Could delay meeting the NII License requirements 4. Prolongs the time that facilities remain a security threat
		Other Considerations	1. Might have significant beneficial socio-economic impacts

Question 9 Issue 4: What is the BPEO for managing the LP & LS effluent streams? Is use of management tools, engineering tools or a combination of management and engineering tools preferred? Have we overlooked any options?

Question 10 In reviewing the LP & LS Baseline BPEO issues, is it helpful to consider options in terms of an overall strategy to guide future BPEO assessments? What aspects of such an overall strategy are most important to you?

Question 11 Do you have any other comments?

10 Summary of Questions

Question 1	Do you have any comments on the overall objective for the remediation of the Legacy Ponds and Legacy Silos facilities and the objective of this Baseline BPEO study?
Question 2	Do you have any comments on the general approach to stakeholder involvement in the Legacy Ponds & Legacy Silos Baseline BPEO study? Do you understand how your feedback will be used to inform programme recommendations for consideration under the Sellafield and NDA strategy?
Question 3	Do you have an appreciation of the constraints and legal requirements applied in screening options for the remediation of the Legacy Ponds & Legacy Silos facilities?
Question 4	Do you have any comments on the issues on which feedback is sought? Have any issues been overlooked?
Question 5	Do you agree that the list of attributes is reasonable? Which attributes are of greatest importance? Have any attributes been omitted that are of particular concern?
Question 6	Issue 1: What is the BPEO for managing risks prior to removal of waste from the LP & LS facilities? Should retrievals from the LP & LS facilities be delayed whilst further engineered protective measures are installed or should retrieval be accelerated without any further measures installed? Have we overlooked any options?
Question 7	Issue 2: What is the BPEO for allowing timely construction of waste treatment facilities? Should retrieved material be stored whilst treatment facilities are constructed or should retrieval be delayed until they are available? Have we overlooked any options?
Question 8	Issue 3: What is the BPEO for the waste package form? Should the legacy wastes be processed into products that (a) meet the Nirex packaging specification for direct disposable to a repository or (b) are basically stabilised or (c) are minimally processed, where basically stabilised or minimally processed products would require re-work to make them disposable to a repository? Have we overlooked any options?
Question 9	Issue 4: What is the BPEO for managing the LP & LS effluent streams? Is use of management tools, engineering tools or a combination of management and engineering tools preferred? Have we overlooked any options?
Question 10	In reviewing the LP & LS Baseline BPEO issues, is it helpful to consider options in terms of an overall strategy to guide future BPEO assessments? What aspects of such an overall strategy are most important to you?
Question 11	Do you have any other comments?