6 SPENT FUEL AND RADIOACTIVE WASTE MANAGEMENT

6.1 What is Radioactivity?

6.1.1 All substances are made of atoms. These have electrons around the outside, and a nucleus, consisting of protons and neutrons in the middle. In some types of atom, the nucleus is unstable, and decays over time into a more stable form of the atom. This is known as radioactive decay.

6.1.2 When an unstable nucleus decays it may give out:

- an alpha particle;
- a beta particle;
- a gamma ray; or
- a combination of these.

6.1.3 The radioactivity of all nuclear waste decays with time. Each radionuclide contained in the waste has a half-life (the time taken for half of its atoms to decay and thus for it to lose half of its radioactivity). Radionuclides with long half-lives tend to be alpha and beta emitters, making their handling easier, while those with short half-lives tend to emit the more penetrating gamma rays. Eventually all radioactive wastes decay into non-radioactive elements. **Table 6.1.1** provides a definition of the three types of radioactive decay.

Table 6.1.1: Types of Radioactive Decay

Term	Description
Alpha activity	Alpha activity takes the form of particles (helium nuclei comprising one proton and one neutron) ejected from a decaying (radioactive) atom. The particles have a very short range in air (typically about 5cm). Alpha particles present in materials outside of the body are prevented from doing biological damage by the outer layer of skin cells, but can cause ionisation and damage in biological tissue if inhaled or swallowed (Ref. 6.1).
Beta activity	Beta activity takes the form of particles (electrons) emitted during radioactive decay from the nucleus of an atom. Beta particles cause ionisations in biological tissue which may lead to damage. Most beta particles can pass through the skin and penetrate the body, but a few millimetres of light materials, such as aluminium, would generally shield against them (Ref. 6.1).
Gamma activity	An electromagnetic radiation similar in some respects to visible light, but with higher energy. Gamma rays cause ionisations in biological tissue which may lead to damage. Gamma rays are very penetrating and are attenuated only by shields of metal or concrete depending on their energy. Their emission during radioactive decay is usually accompanied by particle emission (beta or alpha activity) (Ref. 6.1).

6.2 Measurement of Radioactivity and Dose

6.2.1 There are three fundamental concepts that are important when considering radiation and its effects on physical objects:

- the actual radioactivity involved;
- the amount of energy the radiation imparts to other objects; and
- the biological effects of that radiation.

6.2.2 These concepts are behind the three units most commonly used to measure radiation. The activity of a material is measured in Becquerels (Bq); one Becquerel is one decay per second from an object.

6.2.3 The amount of radiation absorbed by cells is measured in grays (Gy); one gray is one Joule of energy absorbed by 1kg of body mass. This is the dose received.

6.2.4 To measure the impact of radiation on people and the environment we measure the 'dose equivalent' in sieverts (Sv).

6.2.5 **Table 6.2.1** sets out definitions of the units used to measure radioactivity and dose

Table 6.2.1: Radioactivity and Measurement Units

Term	Description
Becquerel (Bq)	The standard international unit of radioactivity is equal to one radioactive decay per second. Becquerels are abbreviated to Bq. Multiples of becquerels commonly used to define radioactive waste activity are: kilobecquerels (kBq) equal to 1 thousand Bq; megabecquerels (MBq) equal to 1 million Bq; gigabecquerels (GBq) equal to 1 thousand million Bq (Ref. 6.1).
Grays (Gy)	Not all radioactive disintegrations impart the same amount of energy on an object. Measuring how much energy is imparted by the radiation is a good indication of how much damage can be caused. The unit gray (Gy) is used to express the energy absorbed from a dose of radiation. A gray has base units of J/kg and expresses the amount of absorbed energy per unit of mass of the affected system.
Sievert (Sv)	The sievert is a unit used to derive equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. To determine equivalent dose (Sv), absorbed dose (Gy) is multiplied by a quality factor (Q) that is dependent upon radiation type and a number of other factors such as the part of the body irradiated, and the time and volume over which the dose was spread.

6.2.6 **Chapter 4 of Volume 1** sets out the legal, regulatory and advisory limits and constraints on the level of radiation to which workers and the public can be exposed. EDF Energy's application for a nuclear license at HPC would need to demonstrate that the proposed operating philosophy ensures that doses to operators and the public have been minimised.

6.3 Radioactive Waste

6.3.1 Any waste material contaminated with or incorporating radioactivity above certain thresholds defined in legislation, and for which no further use is envisaged, is designated as radioactive waste.

6.3.2 Radioactive waste is produced in the UK as a result of the generation of electricity in nuclear power stations and from the associated production and processing of the nuclear fuel, from the use of radioactive materials in industry, medicine and research, and from military nuclear programmes. Radioactive waste must be safely and appropriately managed in ways that pose no unacceptable risks to people and to the environment. This requires a good understanding of the type and characteristics of the radioactive waste to be managed.

6.3.3 How radioactive waste is managed depends to a large extent on how radioactive it is. There are three main categories of radioactive waste defined in UK legislation; these are defined in **Table 6.3.1**.

6.3.4 Some waste which contains very little radioactivity is exempted from regulation by an Exemption Order issued under the Radioactive Substances Act 1993. Exempt waste does not need an authorisation for disposal.

Table 6.3.1: Radioactive Waste Categories

Waste Type	Description
Low Level Waste (LLW)	This comprises materials from routine operations and decommissioning with primarily low concentrations of beta/gamma contamination, but may include small amounts of alpha contaminated material. In the UK LLW may be treated and disposed of through a variety of routes including the national LLW Repository (the LLWR), via commercial incinerators, other treatment facilities, or in certain cases to specific approved landfill (see below). Some LLW which is not suitable for disposal within the LLWR would be stored until the national Geological Disposal Facility is available. In the UK, LLW is defined as waste with a radioactive content exceeding 400kBq in any 0.1m^3 and 40kBq per article (unless the activity is due to carbon-14 or tritium, in which case the limits are a factor of ten greater) but not exceeding 4GBq/te of alpha radioactivity or 12GBq/te of beta/gamma radioactivity. A sub-set of LLW is categorised as Very Low Level Waste (VLLW) which consists of the least radioactive component of the LLW category and may therefore be suitable for alternative disposal or treatment routes. VLLW from nuclear power stations would be classed as High-volume VLLW and could be disposed of to specified approved landfill sites. The waste would be subject to controls on its disposal which would be specified by the environmental regulators.

Waste Type	Description
Intermediate Level Waste (ILW)	Waste containing higher concentrations of beta/gamma contamination and sometimes alpha emitters. There is little heat output from this category of waste. These wastes usually require remote handling. Such waste comes from routine power station maintenance operations, for example used ion exchange resin and filter cartridges. ILW generated during power station operations would be stored in purpose built facilities which may if necessary incorporate shielding to protect operators from radiation. Some ILW is treated as it arises to put it into a more inert, passively safe, form. This is known as conditioning. In the UK, ILW is defined as waste with a radioactive content exceeding that of LLW but which does not require heat dissipation to be taken into account in the design of storage or disposal facilities.
High Level Waste (HLW)	Waste containing high concentrations of alpha/ beta/gamma emitting radionuclides. HLW only arises from nuclear fuel reprocessing operations and therefore would not be generated during operations at HPC. HLW generated during reprocessing of spent fuel requires remote handling (due to the radiation levels) and cooling (due to the heat produced) for many years. In the UK, HLW is defined as waste in which the temperature may rise significantly as energy is released by radioactive decay, so this factor has to be taken into account in designing storage or disposal facilities.

6.4 Spent Fuel

6.4.1 Spent fuel from new nuclear power stations is not categorised as waste because it still contains uranium and plutonium which could potentially be separated out through reprocessing and used to make new fuel.

6.4.2 The 2008 Government White Paper, Meeting the Energy Challenge A White Paper on Nuclear Power Cm7296 (Ref. 6.3) concluded that in the absence of any proposals from the industry any new nuclear power stations that might be built in the UK should proceed on the basis that spent fuel would not be reprocessed and that plans for, and financing of, waste management should proceed on this basis. A description of spent fuel is set out in **Table 6.4.1** below.

Table 6.4.1: Description of Spent Fuel

Waste Type	Description
Spent fuel	Spent Fuel is defined as *"nuclear fuel that has been irradiated in and permanently removed from a reactor core"* (Ref. 6.2). Due to the long half-life of a proportion of the radionuclides contained within spent fuel, its level of activity (and the fact this means it produces heat for long periods) and its fissile content (meaning it has the potential to be recycled and also raises security issues) means that the management of spent fuel is an important issue for the design of any new nuclear power station. The characteristics of spent fuel mean that it is managed in a similar way to HLW due to the high activity and heat generating characteristics.

6.5 UK Radioactive Waste Policy

6.5.1 The development of UK policy on radioactive waste management has been an ongoing process since the start of the nuclear industry in the 1940s. The existing Government policy is set out in the Government White Paper, Review of Radioactive Waste Management Policy Cm2919, as amended (Ref. 6.4). The fundamentals of the policy are that Government would maintain and continue to develop a policy and regulatory framework which would ensure that:

- radioactive wastes are not unnecessarily created;
- such wastes that are created are safely and appropriately managed and treated; and
- they are then safely disposed of at appropriate times and in appropriate ways to safeguard the interests of existing and future generations and the wider environment, and in a manner that commands public confidence and takes due account of costs.

6.5.2 The White Paper 'Managing Radioactive Waste Safety: a Framework for Implementing Geological Disposal' (Ref. 6.1) has sets out the Government's framework for managing higher activity radioactive waste in the long-term through geological disposal, coupled with safe and secure interim storage and ongoing research and development to support its optimised implementation. It also invites communities to express an interest in opening up without commitment discussions with Government on the possibility of hosting a geological disposal facility at some point in the future.

6.5.3 The Government updated its policy on the decommissioning of nuclear facilities in 2004 (Ref. 6.5) which stated that new facilities covered by the policy should be designed and built so as to minimise decommissioning and associated waste management operations and costs.

6.6 UK Disposal Strategy for LLW

6.6.1 LLW has been disposed of in near-surface facilities at the LLWR for many years. However, the existing capacity of the LLWR is less than the forecast volume of LLW that must be dealt with in the future.

6.6.2 The UK Government and the Devolved Administrations carried out a review of solid LLW policy in 2007 (Ref. 6.6) and a new policy was announced that sets out a more flexible approach for managing solid LLW in the long-term. The key aim of the policy statement was to provide a high level framework within which individual LLW management decisions could be taken flexibly to ensure safe, environmentally-acceptable and cost-effective management solutions that appropriately reflect the nature of the LLW concerned.

6.6.3 Under the Energy Act 2004, the Nuclear Decommissioning Authority (NDA) is responsible for developing and implementing a strategy and plans for LLW management and disposal. In 2009 the NDA published a consultation document on the UK Strategy for the Management of Solid Low Level Waste from the UK Nuclear Industry (Ref. 6.7). This proposed a strategy which would provide continued capability and capacity for the management and disposal of LLW in the UK, for both the nuclear and non-nuclear industries through:

- application of the waste management hierarchy;
- best use of existing facilities, working more efficiently and potentially extending the life of the existing national repository; and

- development and use of new fit-for-purpose management and disposal routes, so waste producers have more choice in determining and implementing waste management routes.

6.6.4 The UK LLW strategy is supported by a number of strategic Best Practicable Environmental Option (BPEO) studies covering potential alternatives to the LLWR for metallic wastes, combustible wastes and VLLW. These provide a baseline against which any site can undertake an analysis. A key aspect of achieving the strategy is the improved segregation of wastes to enable alternative disposal routes to the LLWR to be used effectively.

6.6.5 Under the Energy Act 2004, the NDA is responsible for developing and implementing a strategy and plans for LLW management and disposal.

6.7 UK Long-Term Waste Management Solution for ILW and Spent Fuel

a) The Committee on Radioactive Waste Management

6.7.1 Studies into the best disposal options for legacy Higher Activity Wastes (ILW, HLW, and potentially spent fuel) have been ongoing for more than 25 years. In July 2003, the Committee on Radioactive Waste Management (CoRWM) was established by Ministers of the UK Government and devolved administrations of Northern Ireland, Scotland and Wales, to oversee a review of options for managing legacy solid radioactive waste in the UK and to recommend the option, or combination of options, that can provide a long term solution, providing protection for people and the environment.

6.7.2 CoRWM reported its findings in July 2006 and recommended 'geological disposal' as the solution for the long-term storage of the most hazardous legacy radioactive wastes. CoRWM made a total of 15 recommendations to Government (Ref. 6.8). These covered, amongst other topics:

- geological disposal;
- interim storage;
- flexible decision-making;
- research; and
- inviting communities to host a Geological Disposal Facility (GDF).

6.7.3 Recommendations 1 and 2, presented below, provided advice to Government with regard to geological disposal of waste and requirements for interim storage prior to the availability of a GDF.

6.7.4 Recommendation 1: Within the present state of knowledge, CoRWM considers geological disposal to be the best available approach for the long-term management of all the material categorised as waste in the CoRWM inventory when compared with the risks associated with other methods of management. The aim should be to progress to disposal as soon as practicable, consistent with developing and maintaining public and stakeholder confidence.

6.7.5 Recommendation 2: A robust programme of interim storage must play an integral part in the long-term management strategy. The uncertainties surrounding the implementation of geological disposal, including social and ethical concerns, lead CoRWM to recommend a continued commitment to the safe and secure management of wastes that is robust against the risk of delay or failure in the repository programme. Due regard should be paid to:

- reviewing and ensuring security, particularly against terrorist attacks;

- ensuring the longevity of the stores themselves;
- prompt immobilisation of waste leading to passively safe waste forms;
- minimising the need for re-packaging of the waste;
- the implications for transport of wastes.

b) CoRWM position on New Build Wastes

6.7.6 In its 2006 Recommendations to Government (Ref. 6.8), CoRWM made it clear that it takes no position on the desirability or otherwise of nuclear new build and stated that future decisions on new build should be subject to their own assessment process, including consideration of waste. CoRWM emphasised that its recommendations are directed to existing and committed waste arisings and should not be seen as either a red or green light for nuclear new build.

6.7.7 On 25 October 2007 Government re-appointed CoRWM with revised Terms of Reference and a predominantly new membership. These state that:

> *"... The role of the reconstituted Committee on Radioactive Waste Management (CoRWM) would be to provide independent scrutiny and advice to UK Government and devolved administration Ministers on the long-term management, including storage and disposal, of radioactive waste. CoRWM's primary task is to provide independent scrutiny on the Government's and Nuclear Decommissioning Authority's proposals, plans and programmes to deliver geological disposal, together with robust interim storage, as the long-term management option for the UK's higher activity wastes."*

6.7.8 CoRWM has further clarified its position with regard to nuclear new build (Ref. 6.9); a position statement issued by CoRWM in 2010 reiterated that its position on the desirability or otherwise of building new nuclear power stations remains neutral. In March 2010, CoRWM, in their response to Government consultation on the draft National Policy Statements for Energy Infrastructure (Ref. 6.10), also made a number of observations to Government on matters that, in their opinion, should be addressed when considering approval of new nuclear power stations. The observations are wide ranging and include consideration of whether effective arrangements would exist to manage and dispose of waste that would be produced by new nuclear power stations in the UK.

6.7.9 CoRWM's recommendations have been accepted by UK Government for the long term management and disposal of the UK's legacy wastes and have been taken forward in the Managing Radioactive Waste Safely White Paper (Ref. 6.1) described below.

6.8 UK Disposal Strategy for New Build ILW and Spent Fuel

6.8.1 The UK Government has stated that based on scientific consensus and international experience, waste and spent fuel from new nuclear build would not raise such different technical issues compared with nuclear waste from legacy programmes as to require a different technical solution. Government concluded that it would be technically possible and desirable to dispose of Higher Activity Waste from new nuclear power stations in a GDF and that such waste should be stored in safe and secure interim storage until a GDF becomes available (Ref. 6.3).

6.8.2 The principle of geological disposal is to isolate the waste deep inside a suitable rock formation to ensure that no significant quantities of radioactivity ever reach the surface environment. It is the main option on which the NDA conducts research for the long-term management of radioactive waste. It is Government's, and many other nations', preferred long-term approach.

6.8.3 Geological disposal is a multi-barrier, multi-phased approach, based on placing wastes deep underground, beyond disruption by man-made or natural events. The UK Government is currently undertaking a process to identify potential sites for a GDF. The approach is based on voluntarism and partnership with local communities, coupled with the use of appropriate site screening and assessment criteria. Overseas experience, particularly from Sweden and Finland, suggests that such an approach is likely to be an effective way of selecting an appropriate and acceptable site.

6.8.4 The UK Government has invited communities, through the Managing Radioactive Waste Safely (MRWS) White Paper (Ref. 6.1), to express an interest in taking part in the process that would ultimately provide a site for a GDF for the existing inventory of UK Higher Activity Wastes. The NDA is the implementing organisation, responsible for planning and delivering the GDF and, as part of this process, would engage with communities and other stakeholders.

6.8.5 Three local authorities have expressed an interest in entering discussions about the siting process. These discussions are without commitment and are initially about finding out more about what hosting a GDF would mean for a community in the long-term. Partnership working is developing in these communities to help them make a more formal decision about whether to participate further in the process. This process is separate from and is unrelated to the application to build HPC.

6.8.6 The MRWS White Paper notes that *"through agreed mechanisms for updating the Baseline Inventory, inclusion of new waste would be taken forward in discussion with host communities as the programme proceeds. Geological disposal facility design activities would consider the necessary features to safely accommodate particular waste types if that proves necessary"*. It is anticipated that the inclusion of waste from new nuclear power stations would follow this process.

6.9 Radioactive Waste Management Regulation in the UK

6.9.1 The UK Government's radioactive waste management policy is supported by a regulatory framework that aims to ensure that all radioactive wastes are safely and appropriately managed in ways that pose no unacceptable risks to people or the environment. The policy and regulatory framework for nuclear safety, security and environmental protection including spent fuel and radioactive waste management is discussed in Chapter 4 of Volume 1.

6.10 Funding of Waste Management and Decommissioning

6.10.1 The 2008 Nuclear White Paper (Ref. 6.3) sets out the Government's policy that the owners of new nuclear power stations must set aside funds over the operating life of the power station to cover the full costs of decommissioning and their full share of waste and spent fuel management and disposal costs. This includes the costs of providing safe, secure, environmentally acceptable interim storage for spent fuel and ILW until a GDF is ready to accept this material.

6.10.2 The costs for decommissioning, waste and spent fuel management and disposal would be funded through a Funded Decommissioning Programme (FDP), approved by the Secretary of State, which must be in place before the operator uses the site by virtue of the site licence. This ensures that EDF Energy sets aside funds over the operating life of the power station to cover these costs in full.

6.10.3 A legal framework that implements this policy has been established through the Energy Act 2008 and Government also published a consultation on draft FDP guidance in February 2008 (Ref. 6.11), providing further detail on what an FDP should contain. Further consultations on the arrangements for setting a fixed price for waste disposal and the regulations under the 2008 Energy Act were issued in March 2010.

6.10.4 The UK Government has created the independent Nuclear Liabilities Financing Assurance Board (NLFAB), to provide impartial scrutiny and advice on the suitability of the FDP, submitted by operators of new nuclear power stations. NLFAB would advise the Secretary of State on the financial arrangements that operators submit for approval, and on the regular review and ongoing scrutiny of funding.

6.11 HPC Integrated Waste Strategy

6.11.1 Strategic planning of waste management is a regulatory requirement and would be implemented at HPC through the development and production of an Integrated Waste Strategy (IWS). The IWS would set out the logic behind the development of individual waste strategies and how their integration results in the effective management of all the wastes generated by HPC. The IWS would be submitted to the Environment Agency as part of the HPC RSR Environmental Permitting application.

6.11.2 The principal objectives of the IWS are to ensure that a consistent and safe approach is adopted when making decisions on waste management issues, and compliance with environmental protection principles is maintained for all waste types, including materials that may become waste in the future. The IWS recognises that the design of the power station can have an impact on waste management strategy and therefore needs to be taken into account. The IWS aims to ensure that, during the construction, operation and decommissioning of the installation, workers, the public and the environment are protected and that radiation doses are As Low As Reasonably Practicable (ALARP). These objectives are achieved by minimising discharges of radioactivity to the environment through the application of the waste hierarchy and Best Available Techniques (BAT). Definitions of ALARP and BAT are set out in **Table 6.11.1** below.

Table 6.11.1: Minimisation of Dose, Discharges, and Radioactive Waste

Technique	Definition
ALARP	As Low As Reasonably Practicable is an expression used in risk reduction to define a standard or point at which the implementation of additional risk reduction measures would be grossly disproportionate to the benefits achieved.
BAT	Best Available Techniques describe the most effective economically and technically viable technology and methods designed to prevent, and where this is not practicable to reduce, emissions and their impacts on the environment as a whole.
Waste Hierarchy	This concept proposes that minimisation of the creation of waste is the best way to reduce waste, re-use the second best option, followed by recovery (e.g. recycling) and as a last resort disposal.

6.12 High Level Strategy for HPC Radioactive Wastes

a) Solid Radioactive Waste and Spent Fuel Management Strategy

6.12.1 The strategy for solid waste is that they are to be disposed of as soon as practicable where a viable disposal route is available. ILW and spent fuel for which there are no available disposal routes would be accumulated and safely stored on-site in compliance with the requirements of the NSL and RSR Environmental Permit until a suitable disposal route or an alternative management route becomes available.

6.12.2 The disposal of the waste from HPC is expected to follow one of following main routes depending on the radioactivity level and physical characteristics of the waste produced:

- treatment of metals, ultimately for recycling, via commercially available routes subject to meeting the relevant Conditions for Acceptance (CfA);
- incineration of combustible wastes using commercially available routes subject to meeting relevant CfA. There would be no on-site incineration of wastes;
- use of appropriate authorised disposal facilities for exempt and VLLW disposal (notably for soil, rubble and aggregates) where no reuse or recycling options are viable, subject to meeting relevant CfA;
- disposal of LLW at LLWR where the above alternatives are not viable; and
- on-site interim storage of ILW and spent fuel pending the availability of a disposal route.

b) Liquid Radioactive Discharge Strategy

6.12.3 The overall strategy for the management of liquid radioactive discharges from the two UK EPRs planned for HPC, based on the Reference Case presented in the Generic Design Assessment (GDA) for the UK EPR (Ref. 6.12), following the application of BAT is:

- minimising the production of liquid effluents at source;
- partitioning of radionuclides where appropriate to minimise the environmental risks and impacts;
- optimum use of segregation and effluent treatment systems to afford greatest flexibility in their management;
- abatement to capture, concentrate and contain radionuclides, where appropriate, through the use of demineralisation, evaporation and filtration, ensuring the exclusion of all entrained solids, gases and non-aqueous liquids from the discharges;
- optimum use of suitable storage systems for the site, taking advantage of any delay and radioactive decay that may arise;
- assessment and sentencing of liquid effluent prior to discharge to confirm that they are in line with permitted levels;
- where radioactive effluent is discharged into the environment, optimising the manner and timing of any release to minimise the impacts on the environment and members of the public; and
- carrying out routine surveys of the environment to establish that the impact is acceptable.

6.12.4 The management strategy to limit radioactive liquid discharges from the operating activities of the UK EPR is based on the design of the plant and the operational practices to be implemented. The design features use BAT to minimise liquid discharges at source and to minimise the impacts of discharges by means of abatement and discharge plant, and also balance worker doses and costs and the accumulation on-site of additional solid waste incurred as a result of treatment in the plant with any potential reduction in public doses from discharges. Systems and plant are managed and used in a manner so as to minimise so far as reasonably practicable the environmental impacts of discharges, and to ensure that all discharges are monitored and recorded to demonstrate that they fall within the authorised limits.

c) Gaseous Radioactive Discharge Strategy

6.12.5 The overall strategy for the management of gaseous radioactive discharges from the two planned UK EPRs at HPC, and based on the Reference Case presented in the GDA (Ref. 6.12), following the application of BAT is:

- minimising the production of gaseous effluents at source;
- partitioning of radionuclides where appropriate to minimise the environmental risks and impacts;
- abatement of gaseous discharge streams through the use of carbon delay beds to capture noble gases, carbon traps to capture isotopes of iodine and HEPA filters to trap particulate activity;
- monitoring of gaseous effluent prior to discharge;
- where radioactivity is discharged into the environment ensuring the design of the stacks is optimised such that they minimise the impacts on the environment and members of the public; and
- carrying out an agreed environmental survey programme to confirm that off-site impacts are acceptably small.

6.12.6 As with liquid discharges, the management strategy to limit radioactive gaseous discharges from the operating activities of the UK EPR is based on the design of the plant and the operational practices to be implemented. The design features use BAT to minimise gaseous discharges at source and to minimise the impacts of discharges by means of abatement and discharge plant, and also balance worker doses and costs together with the accumulation on-site of additional solid waste incurred as a result of treatment in the plant with any potential reduction of public doses from discharges. Systems and plant are managed and used in a manner so as to minimise so far as reasonably practicable the environmental impacts of discharges, and to ensure all discharges are monitored and recorded to demonstrate that they fall within the authorised limits.

6.13 Management and Storage of Wastes from Other Nuclear Sites

6.13.1 There is no intention to utilise any of the HPC processing, packaging, or interim storage facilities to manage waste from other sites. The facilities described in this document are designed for the sole purpose of managing the wastes generated from the HPC UK EPRs.

6.14 Management of LLW Generated During the Operation of the HPC UK EPRs

6.14.1 The precise volumes of solid LLW produced by HPC is dependent on the future management of the various systems associated with the operation of the nuclear power station. Table 6.14.1

provides the annual estimated production of raw (untreated) LLW for two UK EPRs based on the information presented in the UK EPR GDA submission (Ref. 6.13). The volume and activity of LLW requiring disposal from HPC would be minimised by the use of the Waste Hierarchy and the application of BAT.

6.14.2 Two broad categories of LLW would be generated from the operation of the HPC reactors and auxiliary facilities:

- LLW generated through operation of systems and processes used to ensure safe operation of the power station or to minimise discharges of radioactivity to the environment; and
- LLW generated during maintenance and refuelling operations.

Table 6.14.1: Categories of LLW that would be Generated at HPC

Waste Type	Waste Description
Steam Generator Blowdown System (SGBS) Ion-Exchange Resins	Ion exchange beds are utilised in the SGBS to trap activation and fission products from the primary coolant circuit. In recycling the SGBS blowdown water from the UK EPR secondary circuit, the blowdown water is purified by the use of two parallel filters for the removal of suspended solids and two parallel demineralisation lines which use ion exchange resins to perform the demineralisation.
LLW Wet Sludge	During the operation of the HPC UK EPRs, particulates would settle as sludges in various buffer and storage tanks associated with the auxiliary water circuits (e.g. Liquid Waste Treatment System, Liquid Effluents Release System). These are contaminated with a range of fission and activated corrosion products. This sludge is periodically cleaned out and removed for treatment prior to disposal.
LLW Cartridge Filters from auxiliary circuit treatment	Filters are used to capture particulate material in the UK EPR water auxiliary circuits. Spent filter cartridges arise from the treatment lines of the following water auxiliary circuits: Chemical and Volumetric Control System, Boron Recycle System, Liquid Waste Treatment System, and the Spent Fuel Storage Compartment Treatment System. Water filters are withdrawn from operation on the basis of clogging and/or dose rate and then treated as waste. The physical form of this waste stream consists of filter cartridges that are composed principally of stainless steel supports with glass fibre filter media and some organic materials. The amount of particulate radioactive material (metallic oxides) trapped on each filter can vary. The majority of waste within this category is anticipated to be ILW at the point of generation but some LLW is expected.
Evaporator Concentrates	The UK EPR proposes to make use of evaporation for the minimisation of radioactive liquid effluents arising from the non-recyclable Liquid Waste Treatment System. Evaporation would be used to minimise the discharge of active aqueous effluents to the environment. Evaporation of effluents results in

Waste Type	Waste Description
	the production of a sludge-like concentrate that would contain the bulk of the radioactivity initially present in aqueous effluent streams as activated metal oxides.
Air Filters	All radiation controlled areas of the nuclear auxiliary building, fuel building, safeguards buildings, reactor building, operational production centre, access building and waste treatment building are served by dedicated ventilation systems. The extract from these systems is subject to a number of airborne activity abatement techniques, including the use of High Efficiency Particulate Air (HEPA) filtration, before discharge to the environment. The HEPA filters remove particulate material to ensure doses to workers are ALARP and discharges to the environment are minimised. This also ensures that the doses to members of the public from airborne discharges are minimised. The abatement systems would produce a number of spent LLW HEPA filters over the course of reactor operations.
Water Filters	Water filters may arise from filtering of the low active effluent (Gaseous Treatment System, Liquid Waste Treatment System, Steam Generator Blowdown System). The physical form of this waste stream consists of filter cartridges that are composed principally of stainless steel supports with glass fibre filter media and some organic materials. The amount of particulate radioactive material (metallic oxides) trapped on each filter can vary.
Dry Active Wastes	Dry Active Wastes (DAW) comprise the combustible and non-combustible LLW generated through routine and maintenance operations in the UK EPR nuclear island and consist of contaminated personal protection equipment, monitoring swabs, plastic, clothing, contaminated tools, segregated pieces of metal, glassware and other process consumables. These wastes mainly arise during outages.
Oils and Solvents	Oils are used in the lubrication of various components such as circulators and process pumps and have the potential to become radiologically contaminated during normal service. Contaminated liquids such as chemical cleaning solutions and solvents used as decontamination agents also arise and would be included within this waste stream.
Metal Scraps and other metallic wastes (Dose rate < 2 mSv/h)	During maintenance operations a variety of metal wastes can be generated, arising from the replacement of engineering components. The redundant metal components or equipment used during the maintenance operations in the nuclear island may become contaminated and require disposal as radioactive waste.

6.15 Arrangements for Site LLW Management

6.15.1 Detailed arrangements for radioactive waste management would be covered in EDF Energy operating procedures required to demonstrate compliance with Nuclear Site Licence (NSL) and Radioactive Substances Regulation (RSR) requirements. For LLW, these instructions are anticipated to cover minimisation, segregation, characterisation/assessment, packaging, labelling, record keeping and consignment for transfer/disposal.

6.15.2 The design of the UK EPRs incorporates a number of measures aimed at minimising the amount of solid wastes by facilitating the segregation and volume reduction of solid wastes, taking account of the review of the performance and operating experience of existing reactors. Examples include:

- the composition of the primary circuit component materials has a direct impact on the radioactive inventory in the primary coolant, especially on the activation of corrosion products. Therefore, chemistry and radiochemistry are optimised in the UK EPR design to reduce the primary circuit radioactive inventory and lower the dose rate levels, which in turn would minimise the activity of corrosion products which contribute to solid waste arisings;
- improved efficiency of recycling (e.g. coolant) and effluent processing systems to reduce solid waste volumes associated with the treatment of coolant and effluents; and
- zoning of rooms and controlled areas to maximise the segregation of radioactive and non-radioactive wastes and thus minimise radioactive waste arisings.

6.16 Facilities to be Provided for Site LLW Management

6.16.1 LLW generated during the operational period from both the reactors and the associated auxiliary plant would be transferred to the Effluent Treatment Building (ETB) of UK EPR Unit 1. This facility is designed to manage waste through segregation and application of suitable treatments in preparation for disposal. LLW would be processed and packaged as required to meet the CfA of the appropriate off-site disposal facility.

6.16.2 LLW would be safely transferred from different locations in the radiation controlled area to the ETB. Waste would be collected and stored according to waste activity categorisation at dedicated locations in the ETB and placed into a temporary buffer store prior to treatment. The waste would then be separated on the basis of the treatment method and would be stored in these areas until sufficient quantities have accumulated for a treatment campaign to start or for shipment off-site.

6.16.3 The treatment of solid waste is determined (once it has been monitored and assayed) generally by the categorisation of the waste together with its physical and chemical characteristics.

6.16.4 Once categorised the waste would be packaged (and conditioned if necessary) and transferred off-site to the most appropriate facility for its treatment (such as super-compaction, melting or incineration) or disposal.

a) Segregation

6.16.5 Solid wastes would, as far as practicable, be segregated and sorted at source to minimise secondary handling. Waste streams that generate mixed wastes would be sorted in a dedicated unit within the ETB to optimise their subsequent management and disposal. If no further benefit can be obtained from further segregation then the waste would be transferred to the next stage.

6.16.6 The segregation of the waste into different waste groups would be carried out on the basis of different physical and chemical properties, e.g. combustible, non-combustible and compactable waste, and non-compactable waste.

b) Shredding

6.16.7 Bulky solid combustible and compactable waste may be size reduced by shredding in the ETB prior to further treatment. The waste is size reduced by the use of a rotating blade assembly. The shredded material then falls through a duct into a compactable drum located directly below the shredder. Once full, the drum would be returned to the storage area and temporarily stored until a sufficient volume of waste for treatment or disposal is collected.

c) Low Force Compaction

6.16.8 A low force compactor in the ETB would be used on-site to assist in the volume reduction of appropriate wastes prior to transfer off-site for disposal.

d) Conditioning of LLW for Disposal

6.16.9 Some LLW, e.g. sludges and resin, may require processing within the ETB either by dewatering, drying, or encapsulation in a mortar matrix within the waste disposal package prior to transfer from the site in order to meet the CfA for the proposed disposal site.

e) Handling and Transfer of Final Packages

6.16.10 Following treatment, the waste would be placed in an appropriate container for transport or disposal. After being sealed, the containers would be checked for the presence of external contamination prior to transfer out of the ETB. Waste containers awaiting transfer off-site would be placed in buffer stores and transferred into transportation containers prior to loading onto the transportation vehicle.

6.17 LLW Volume Estimates

6.17.1 The LLW volume estimate is based on a review of the waste arisings from existing French nuclear reactors of similar power rating to the UK EPR, performed as part of the GDA process (Ref. 6.13). It is assumed at present that HPC, with two UK EPRs, would produce double the arisings predicted for one unit in the GDA, even though some facilities would be shared. The sharing of facilities, such as the waste treatment facilities, may result in some reduction of operational arisings. However, at this stage it is not possible to make precise predictions of reductions so the figures set out in **Table 6.18.1** are considered to present a best estimate of solid LLW arisings.

6.18 LLW Disposal Strategy

6.18.1 The strategy for LLW is that waste generated throughout nuclear power plant operations and decommissioning would be disposed of as soon as reasonably practicable, following treatment to minimise volume and perform appropriate conditioning or packaging. The ultimate disposal of the wastes is expected to be via one of the following main routes depending on the radioactivity level of the waste produced, its physical characteristics and its chemical properties:

- treatment of metals, ultimately for recycling, via commercially available routes subject to meeting the relevant CfA;

- incineration of combustible wastes using commercially available routes subject to meeting relevant CfA. There would be no on-site incineration of wastes;
- use of appropriate authorised disposal facility for exempt and VLLW disposal (notably for soil, rubble and aggregates) where no reuse or recycling options are viable, subject to meeting relevant CfA;
- transfer of suitable LLW for super-compaction prior to disposal at the Low Level Waste Repository (LLWR) to minimise disposal volume; and
- disposal of LLW directly to LLWR would be utilised only where the above alternatives are not practicable.

6.18.2 For all LLW (other than for the small volume of oils and solvents where disposal via incineration is considered to be the preferred option) acceptance for disposal of the generic LLW arising from operation of a UK EPR has been agreed in principle with LLW Repository Ltd during the GDA process. In order to demonstrate the acceptability of the non-LLWR disposal routes for HPC LLW a process has been initiated to obtain disposability in principle for the wastes.

6.18.3 EDF Energy has reviewed the potential treatment and disposal options for LLW from HPC. The preferred options for management of LLW generated at HPC are set out in **Table 6.18.1** and diagrammatically in **Figure 6.18.1**. Conditions and limits would be set, by the Environment Agency, for the transfer of LLW in the HPC RSR Environmental Permit issued under the Environmental Permitting Regulations 2010.

a) Off-Site Metal Recycling Facility Operations

6.18.4 Where the metallic waste generated by operational maintenance work cannot be adequately decontaminated on-site, the waste would be transferred to an off-site commercial Metal Recycling Facility (MRF) e.g. Studsvik Metal Recycling Facility at Lillyhall, Cumbria. The volume of metallic waste requiring disposal could be reduced by up to 95% (Ref. 6.15) using metal recycling techniques.

6.18.5 Once transferred to the MRF, a range of industrial cutting and cleaning techniques would be applied. The metallic waste is decontaminated and cleaned using methods such as dry grit blasting so that the resulting materials can either be recycled in the UK or potentially sent to a facility for further cleaning by melting.

b) Off-Site Incineration Operations

6.18.6 LLW would be segregated within the ETB to separate combustible waste from non-combustible. Combustible waste suitable for incineration would be transferred to an off-site commercial incinerator and incinerated in a specially engineered kiln up to around 1000°C. Any gases produced during incineration are treated and filtered prior to emission into the atmosphere and would conform to international standards and national emissions regulations.

6.18.7 Incineration of combustible wastes is applied to both radioactive and other wastes in the UK. In the case of radioactive waste, incineration has been used for the treatment of LLW from nuclear power plants, fuel production facilities, research centres (such as biomedical research), the medical sector and waste treatment facilities.

6.18.8 Modern incineration systems are well engineered and designed to burn the waste efficiently whilst producing minimum emissions. Ash remaining following incineration would be disposed of as appropriate.

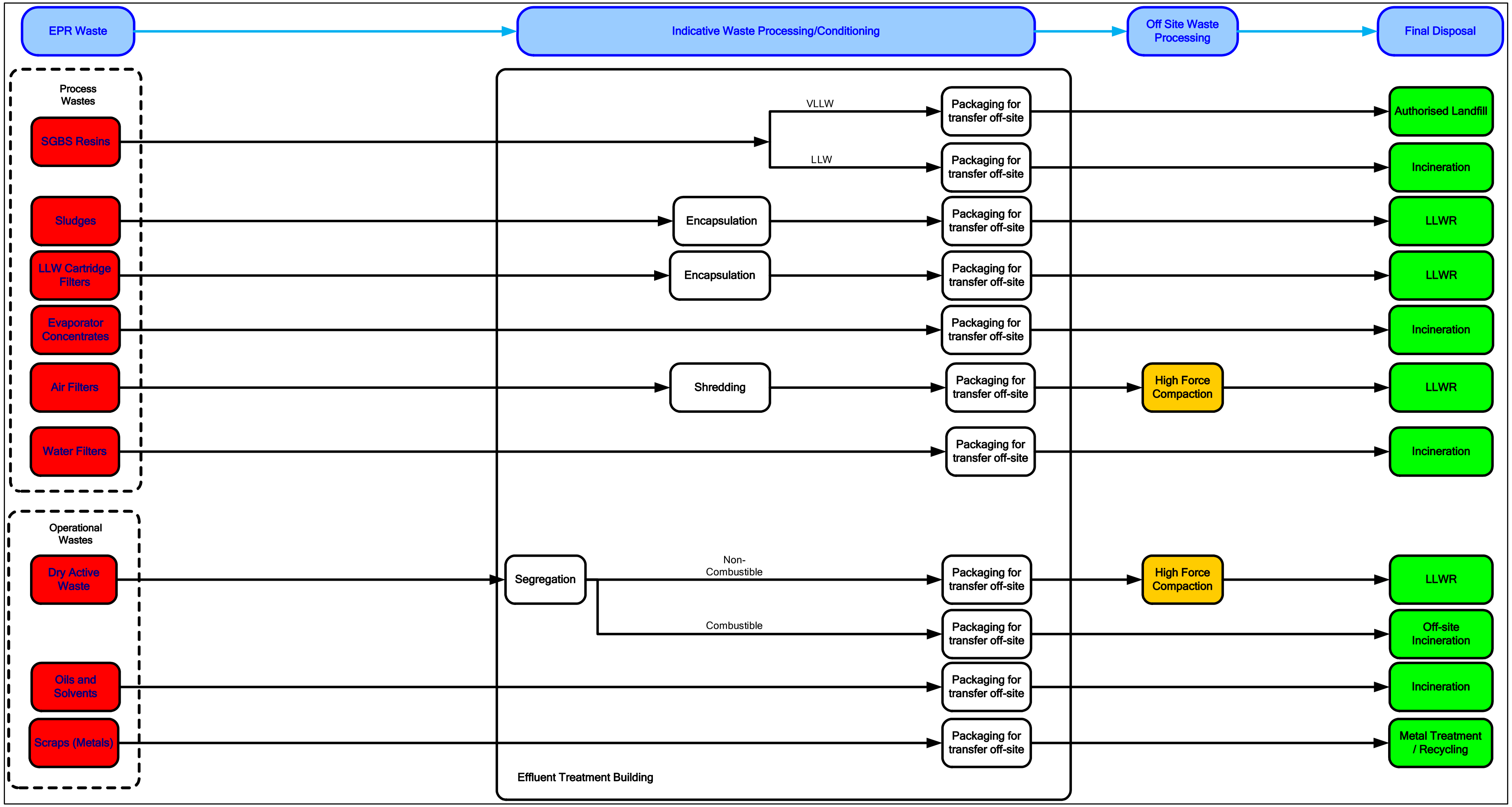
c) Off-Site Super Compaction Facility Operations

6.18.9 Suitable LLW would be transferred off-site to a super compaction facility to minimise its volume. In this process drums or boxes of waste are compacted under high pressure of up to 2,000 tonnes per square metre. Following super compaction the drums would be transferred onward to LLWR for disposal.

d) LLWR Operations

6.18.10 LLW unsuitable for disposal via the above disposal routes, but which meets the CfA for LLWR (Ref. 6.14), would be packaged on-site and transferred directly for disposal to LLWR in approved transport packages e.g. Half Height ISO Containers (HHISO).

Figure 6.18.1– Indicative LLW Processing and Disposal Strategy



Note these disposal routes represent the preferred option for LLW management and disposal based on the anticipated waste characteristics. Alternative routes may be utilised in the future if they can be demonstrated to represent BAT or if the above disposal routes are found to be unavailable.

Table 6.18.1: LLW Generation, Processing and Disposal Strategy

Waste Type		Estimated Raw Waste Volume annual (m^3)	Preferred Waste Arrangement	Alternative Waste Arrangement
Steam Generator Blowdown System APG (SGBS) Ion-Exchange Resins		15	Package as required to meet CfA and transfer for Disposal as VLLW	Transfer for Incineration Direct disposal to LLWR
Wet Sludge (from sumps, tanks)		1	Condition/package as required to meet CfA and transfer for disposal to LLWR	
LLW Cartridge Filters from auxiliary circuit treatment		0.10	Condition/package as required to meet CfA and transfer for disposal to LLWR	
Evaporator Concentrates		6	Package and transfer for off-site Incineration	Direct disposal to LLWR
Air and Water Filters		8	Transfer for Incineration (Water Filters)	Direct disposal to LLWR
			Transfer for High Force Compaction (Air Filters) and onward disposal to LLWR	
Dry Active Wastes (excluding metals)	Non-Combustible	25	Transfer for High Force Compaction and onward disposal to LLWR	Direct disposal to LLWR
	Combustible	75	Package and transfer for off-site Incineration	Direct disposal to LLWR
Waste Oils and Solvents		4	Package and transfer for off-site Incineration	
Metal Scraps and metallic Waste		12	Package and transfer for Metals Treatment	Direct disposal to LLWR

6.19 Transport Arrangements for LLW

6.19.1 As set out in **Chapter 4 of Volume 1** all radioactive waste transferred from the site would need to comply with applicable UK and international legislation at the time of despatch, including the relevant requirements of the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (Ref. 6.16). Each consignment would undergo the required contamination checks and external radiation measurements before leaving the site.

6.19.2 Radioactive waste is transported in specially designed and approved packages. The packages provide protection to operators and members of the public and are required to be sufficiently robust to withstand an accident.

6.20 Potential Impacts of LLW Management Activities

6.20.1 The potential impacts associated with LLW management activities proposed at HPC have been considered as part of the HPC construction and operational assessments within the specific chapters of this Environmental Appraisal. **Table 6.20.1** identifies where the potential impacts associated with the construction, operation and decommissioning of LLW management facilities are covered in greater detail.

Table 6.20.1: Potential Adverse effects of LLW Management Activities

Activity	Impact	Volume/Chapter
Processing of LLW for off-site transfer	The processing of LLW in preparation for off-site transfer and disposal would take place within purpose built facilities. These processes would result in small discharges of radioactivity and would represent a minor proportion of the HPC site total discharges. The impact of HPC radiological discharges is considered within the 'Radiological Impact Assessment' chapter of this volume.	Volume 2 Chapter 20
Storage of LLW	The temporary storage of LLW on the site prior to transfer for treatment or disposal would have minimal impact on off-site dose from direct radiation or from discharges due to the very low specific activity of the waste and the controls that would be in place. The implications of direct dose from HPC are considered in the 'Radiological Impact Assessment' chapter of this volume.	Volume 2 Chapter 20
Construction of LLW management facilities	The construction of buildings associated with LLW management would be part of the main on-site construction activities. The impact of construction activities at HPC is considered within the 'Construction of Hinkley Point C' chapter of this volume.	Volume 2 Chapter 3

Activity	Impact	Volume/Chapter
Transport of LLW to off-site disposal facilities	Transport of LLW from HPC for off-site disposal or treatment would be anticipated to result in a small number of additional annual HGV movements from the site to the disposal/transfer facilities. The impact of transport during operation of HPC is considered within the 'Transport' chapter of this volume.	Volume 2 Chapter 9
Decommissioning of LLW management facilities	Impacts regarding the decommissioning of the LLW management facilities have been reviewed within the 'Decommissioning of Hinkley Point C' chapter of this volume.	Volume 2 Chapter 5

6.21 Timing of the Decommissioning of LLW Facilities

6.21.1 The LLW processing facilities would be utilised for the management of wastes throughout the operation of both of the HPC UK EPRs. It is anticipated that the LLW processing facilities would be decommissioned in the final stages of the main decommissioning phase as set out in Volume 2 Chapter 5.

6.22 Management of ILW Generated during Operation of the HPC UK EPRs

6.22.1 Routine operation of the HPC reactors and their associated auxiliary systems would generate ILW. The majority of ILW would arise from the treatment of liquids and gases in order to reduce worker doses and discharges of radioactivity to the environment e.g. ion exchange resins.

6.22.2 In addition to the process wastes, a variety of ILW streams may be generated as a result of maintenance work carried out during reactor operation and work performed during reactor outages.

6.22.3 The ILW streams that are anticipated to arise from normal operation and maintenance of the two UK EPRs at HPC are set out in **Table 6.22.1** below.

Table 6.22.1: Categories of ILW that would be Generated at HPC

Waste Type	Waste Description
ILW Ion exchange resins	Ion exchange beds are used to capture and minimise soluble radioactive material. This material results from corrosion in the primary circuit (mainly in the steam generators and activation of chemicals in the primary circuit) and in the following UK EPR water auxiliary circuits: • Chemical and Volumetric Control System; • Coolant purification system; and • Spent Fuel Storage Compartment Treatment System. The ion exchange resins in the beds are periodically changed to optimise their performance. Additional volumes of ILW ion exchange resins may arise from the maintenance of water quality and the abatement of liquid discharges from the spent fuel Interim Storage Facility.
ILW cartridge filters	This waste consists of filters used in the clean-up of primary circuit water and water from the Liquid Waste and Spent Fuel Pond Treatment Systems. There are several designs of filters depending on the abatement required. A proportion of the filters generated would fall into the ILW category.
ILW Sludges	During the operation of the HPC UK EPRs, particulates would settle as sludges in storage tanks associated with the auxiliary water circuits e.g. Liquid Waste Treatment System. These are variously contaminated with a range of fission and activated corrosion products. This sludge would be periodically cleaned out and removed for treatment prior to disposal. The waste is a sludge consisting of settled particulate. A proportion of the sludge generated would fall into the ILW category.
Operational wastes >2mSv/hr	This comprises a range of materials, including activated core components, contaminated metal, plastics, cloth, glassware and rubble, arising from operations during planned shutdown periods. Some activated components generated during maintenance operations may be temporarily placed into the reactor fuel pools to allow for a period of radioactive decay until decommissioning and would be treated as a decommissioning waste in order to minimise dose to workers.

6.23 ILW Management Strategy for HPC

6.23.1 The strategy is for ILW to be retrieved, conditioned and packaged on-site on a campaign basis throughout the operational phase. Waste processing would result in a passively safe package ready for interim storage. The passively safe packages would be stored in an interim ILW store for the duration of operations. The stored ILW packages would be removed from the ILW store when a GDF is available to accept new build waste for final disposal. The assumed timescales for store emptying are discussed later in this chapter.

6.24 Storage of Waste for Re-Categorisation

6.24.1 The radioactivity of all radioactive waste diminishes with time (known as radioactive decay). All radionuclides have a half-life (the time it takes for any radionuclide to lose half of its radioactivity) and eventually all radioactive waste decays into non-radioactive elements. The process of waiting for a natural decline in the level of radioactivity to allow waste to be disposed of as a lower category of waste is known as decay storage.

6.24.2 The radioactivity of a proportion of the ILW that would be generated during operation of the HPC UK EPRs would be dominated at the time of arising by relatively short lived radionuclides including cobalt-60 (half life of 5.27 years), caesium-137 (half life of 30.2 years) and iron-55 (half-life of 2.7 years). After a period of interim storage, the radioactivity of some of this waste would have reduced to such levels that the waste would no longer be classified as ILW. This waste would therefore be managed as LLW.

6.25 Disposability of ILW from HPC

6.25.1 Before conditioning and packaging of ILW, regulatory arrangements require that sites produce an ILW conditioning proposal. This would include a demonstration that, following conditioning, the waste would be compatible with existing or future planned management and disposal options. This requires that a Letter of Compliance (LoC) is obtained for the packaging proposal. The LoC process is the mechanism that the NDA Radioactive Waste Management Directorate (RWMD) utilises to provide confidence that a waste package can be accepted at a future GDF.

6.25.2 The overall objective of the LoC assessment process is to give confidence to all stakeholders that the future management of waste packages has been taken into account as an integral part of their development and manufacture. This is achieved by the site operator working with RWMD to demonstrate that the waste packages produced by a proposed packaging process would be compliant with the generic waste package specification and compatible with plans for transportation and emplacement in the planned future geological repository.

6.25.3 In cases where the assessment has concluded that the waste package is compliant with the repository concept and underpinning assessments, RWMD is prepared to confirm this by the issue of a LoC.

6.25.4 As part of the GDA process, the opinion of the RWMD was sought on the likely acceptability for disposal in a GDF of packaged ILW generated by UK EPR. RWMD was asked for its views on a number of different waste packages, including those that would be produced by implementing the GDA reference strategy for on-site ILW management. RWMD indicated that, in principle, any of the proposed waste packages would be acceptable for disposal. EDF Energy would continue to work with RWMD through the LoC process to ensure that packaged ILW from HPC would be acceptable for disposal in a GDF (Ref. 6.17).

6.26 Description of the 'Reference Case' for ILW Processing

6.26.1 The proposed strategy for ILW conditioning and packaging at HPC is termed the 'Reference Case'. It assumes that operational ILW would be conditioned and treated using the same procedures as applied during the operation of existing PWRs in France with due consideration for UK specific requirements.

6.26.2 Under the Reference Case strategy two types of cylindrical pre-cast concrete casks, designated C1 and C4, are the packages to be utilised for all operational ILW. Both of these casks can include internal mild steel shielding of flexible thickness to provide shielding against different concentrations of gamma emitting radionuclides. The C1 Cask is 1.4m in diameter, 1.3m high, and has a 0.15m thick concrete shield wall. The C4 Cask has the same dimensions apart from the diameter which is 1.1m. In the Reference Case scenario, the operational ILW would be immobilised within the casks using epoxy resin or cement grout prior to being placed into the on-site interim ILW store.

6.27 Arrangements for Site ILW Management

6.27.1 Arrangements and requirements for radioactive waste management would cover minimisation, segregation, quantitative assessment, packaging, labelling, record keeping and consignment for transfer/disposal (Ref. 6.18).

6.27.2 Processes would be established and implemented for the packaging of radioactive wastes that encompass the whole lifetime of waste packages to ensure that packaged waste has the properties ascribed to it. These arrangements would be reviewed periodically and adequate records maintained.

6.27.3 The management arrangements would apply to all activities, interactions and aspects that can affect the quality of the waste package product, including:

- waste characterisation;
- container design;
- container manufacture;
- wasteform development;
- process development;
- plant specification and design;
- LoC submissions and advice actions;
- plant commissioning and operation;
- raw materials storage;
- waste package interim storage and monitoring;
- control of non-conforming packages;
- change control and continual improvement of waste package design, processing plant and interim storage; and
- package records and their long-term retention.

6.28 Facilities for Site ILW Management

6.28.1 ILW generated on the HPC site would require conditioning and packaging into an acceptable (passively safe) form prior to interim storage. This process is described in the following sections.

6.28.2 Based on current UK radioactive waste policy and strategy the intention is that the final disposal location of packaged ILW from HPC would be in a GDF. However since the volume of LLW estimated to be generated from legacy and potential new build is greater than the capacity at the current LLWR it is considered that a new LLW disposal site would need to be constructed in the future. A potential solution for consideration could be that, as in France, this new site could accept both LLW and short lived ILW, which would limit the volume of ILW requiring disposal to a GDF from new build operators mainly to activated core components and other ILW decommissioning waste.

6.29 ILW Processing and Packaging

6.29.1 ILW generated during the UK EPR operation would be conditioned in the ETB. The ETB is the single interface for the processing of all radioactive operational waste materials that would be generated by the operation of the UK EPR and includes functions for safe handling, treatment, conditioning, buffer storage, packaging and monitoring of wastes prior to transfer of packages to the ILW Interim Storage Facility (ILW ISF).

6.29.2 The key waste management functions are:

- treatment of radioactive wastewater and effluent;
- treatment of solid waste; and
- conditioning of solid/liquid waste (including cementation and resin encapsulation).

6.29.3 The conditioning process for the treatment of the waste would ensure the waste is in a passively safe form to be transferred from the ETB to the ILW ISF and the waste package itself would be compliant with the requirements of RWMD.

6.30 ILW Cementation

6.30.1 Cementation through the use of specially formulated grouts provides a means to immobilise radioactive material that is either solid or in various forms of sludges. At HPC, it is anticipated that all ILW wastes, other than Ion Exchange Resins, would be conditioned utilising a cementation process.

6.30.2 In general the solid wastes are placed into containers. The grout is then added into this container and allowed to set. The container with the now monolithic block of concrete/waste is then suitable for storage and disposal.

6.30.3 Similarly in the case of sludges the current packaging assumption is that the waste would be placed in a container and a grouting mix, in powder form, is added. The two are mixed inside the container and left to set leaving a similar type of product as in the case of solids, which can be disposed of in a similar way.

6.31 ILW Epoxy Resin Encapsulation

6.31.1 Ion exchange resins consist of small beads used to remove radioactivity from contaminated liquids. The radioactive ions in the liquid are absorbed onto the resin by the chemical process of ion exchange. The resins retain the activity and the cleaned liquids can then be safely disposed of. When the ability of the resins to absorb more radioactive ions is exhausted they become radioactive waste.

6.31.2 It is proposed that spent ion exchange resins would be processed by in-drum solidification utilising a polymer solidification process. The process is established as a technique for treating ILW ion exchange resins in the UK, at the Magnox site at Trawsfynyyd, and in France using mobile processing units.

6.32 Summary of ILW Strategy and Volumes

6.32.1 The baseline processing strategy for the HPC ILW streams is summarised in Table 6.32.1. The proposed baseline set out in the table is the Reference Case for ILW processing which has been used to demonstrate that a suitable strategy can be implemented to manage the waste streams.

Table 6.32.1: Operational ILW Waste Generation and Proposed Management Strategy for the HPC UK EPRs

ILW Stream	Waste Description	Anticipated Annual Raw Waste Volume from two UK EPRs (m^3)	Lifetime (60yr) Raw Waste Volume from two UK EPRs (m^3)	HPC Processing Strategy	Anticipated Lifetime (60yr) Package Numbers from two UK EPRs
ILW Ion exchange resins	Organic resins that arise from the clean-up of primary circuit water, water from the effluent treatment systems and the reactor fuel pools.	6	360	Polymer immobilisation in Concrete C1 casks. Followed by interim storage on-site awaiting availability of a GDF.	900
ILW Spent cartridge filters	Filters from the clean-up of primary circuit water and water from the Liquid Waste and Spent Fuel Treatment Systems. The filters consist of a stainless steel support, with a glass fibre or organic filter media.	5	300	Cement grouted in Concrete C1 casks. Followed by interim storage on-site awaiting availability of a GDF.	720
	Other designs of filters, typically with lower activity.	5	300	Cement grouted in Concrete C4 casks. Followed by interim storage on-site awaiting availability of a GDF.	1200
Operational wastes ›2mSv/hr	A range of materials, including activated core components, contaminated metal, plastics, cloth, glassware and rubble arising from operations during planned shutdown periods.	2	120	Cement grouted in Concrete C1 casks. Followed by interim storage on-site awaiting availability of a GDF. Note: Activated core components with heat generation levels above the ILW categorisation would be transferred to the Reactor Fuel Pool where they would be held for a period of delay storage before processing.	360

ILW Stream	Waste Description	Anticipated Annual Raw Waste Volume from two UK EPRs (m^3)	Lifetime (60yr) Raw Waste Volume from two UK EPRs (m^3)	HPC Processing Strategy	Anticipated Lifetime (60yr) Package Numbers from two UK EPRs
ILW Wet sludge	Sludge arising from cleaning the bottoms of liquid waste treatment tanks and various sumps.	2	120	Cement grouted in Concrete C1 casks. Followed by interim storage on-site awaiting availability of a GDF.	480
Totals		$20m^3$	$1200m^3$		3660 Packages

Waste generated from spent fuel Interim Storage Facility

An additional volume of ILW may be generated during the operation of the spent fuel Interim Storage Facility. The detailed design of the spent fuel Interim Storage Facility is in progress and as such the abatement systems and waste volume generation has not yet been finalised. All waste resulting from the operation of the spent fuel Interim Storage Facility is expected to fall into the categories set out above, or the previously discussed LLW categories. The main solid waste streams are anticipated to be spent ion exchange resins and filters; these would be expected to be processed as above followed by interim storage on-site awaiting availability of a GDF.

6.33 Interim On-Site Storage of ILW

6.33.1 There is currently no ILW disposal facility in the UK. The GDF is not expected to be available for disposal of wastes for a number of years after HPC starts operations. The strategy for ILW management at HPC is, therefore, to process and store the waste on-site, according to the principles of passive safety (Ref. 6.19), pending availability of the GDF.

6.33.2 The key requirement of the interim store would be to provide protection for the waste packages from potential degradation which could have a long-term impact on the integrity of the package and eventual acceptance of the package at GDF. In terms of containment of radioactivity and prevention of releases which could impact upon the outside environment, a number of barriers and environmental controls are provided as listed below:

- the conditioned wasteform is the primary barrier, e.g. the cemented matrix;
- the waste container is the secondary barrier, e.g. the concrete package;
- control of the store environment is important in maintaining integrity of the waste container to ensure compliance with LoC requirements, e.g. humidity levels controlled by adequate ventilation; and
- the store structure is the final layer of weather protection for the waste package and also provides a role in the physical security of the waste.

6.33.3 The store would require appropriate maintenance and various levels of in-service refurbishment. As a condition of the Nuclear Site Licence, the facilities on-site, including the ILW ISF, would be subject to Periodic Review of the safety case throughout the operational life of the store, ensuring any necessary improvements would be made in a timely manner.

6.33.4 The required maximum lifespan of the ILW ISF is expected to be approximately 100 years, in accordance with the timeline for GDF availability assumptions, but its lifespan is considered to be capable of extension through refurbishment or replacement of equipment and structures.

6.33.5 The facility is designed to receive and store packages of ILW waste arising from the planned 60 years of operation of the two UK EPRs on the HPC site. The waste would be packaged into a passively safe state prior to being transferred to the ILW interim storage facility.

a) Facility Design Description

6.33.6 The final design of the ILW ISF has not been completed but it is anticipated that it would consist of areas performing the following functions:

- receipt and dispatch area;
- interim storage space for all operational ILW until a GDF becomes available;
- package inspection area; and
- facilities to manage ILW that would become LLW following a period of decay storage.

6.33.7 The facility would also require a number of auxiliary systems and facilities, such as electrical power unit, ventilation system unit, and maintenance area.

b) Safety Aspects

6.33.8 The facility would be designed, constructed and operated to comply with Ionising Radiation Regulations 1999. In order to minimise radiation doses to workers and the public, the facility would include the following safety functions:

- the facility would provide containment for radioactive material. In most instances the primary containment would be provided by the conditioning process and the waste packages and secondary containment by the facility structure;
- the facility would limit the radiation exposure of workers and the public through the provision of shielding; and
- the facility would be maintained at a reduced pressure through the use of a filtered ventilation system to prevent any spread of contamination in the event of an incident at the facility.

6.33.9 Further measures would be implemented to prevent the risk of a loss of containment from a waste package including:

- minimising waste package handling operations and where practicable minimising the lift height of packages, where package movements cannot be avoided;
- inspection and monitoring of the waste packages in the storage hall to allow early intervention if any package defect is identified; and
- the waste packages are designed to be robust against impact and or being dropped during package movement operations.

6.34 Timing of Decommissioning of ILW Management Facilities

6.34.1 The ILW processing facilities would be utilised for the management of wastes throughout the operation of both of the HPC UK EPRs. It is anticipated that the ILW processing facilities would be decommissioned in the final stages of the main decommissioning phase as set out in **Chapter 5** of this volume.

6.34.2 The ILW ISF would be decommissioned following complete transfer of all waste from the store; the anticipated timing of transfer of ILW from the store is set out below.

6.35 Transport of ILW to GDF

6.35.1 At the end of the interim storage period it is the responsibility of the waste producers to ensure that the package is safe for export off-site and is compliant with transport regulations in force at that time. Assessments for the LoC process also address transportation so packages in receipt of a LoC can have confidence that transportation issues have been addressed.

6.35.2 As set out in **Chapter 4** of this volume all radioactive waste despatched from the site would need to comply with applicable UK and international legislation at the time of despatch, including the relevant requirements of the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (Ref. 6.16). Each consignment would undergo the required contamination monitoring and external radiation measurements before leaving the site.

6.35.3 Radioactive waste is transported in specially designed and approved packages. The packages provide protection to operators and members of the public and are required to be sufficiently robust to withstand an accident.

6.36 Disposal of ILW to GDF

6.36.1 In planning the implementation of the national policy of geological disposal, the NDA has assessed that a UK facility could be operational for the disposal of legacy ILW by about 2040. Disposal of legacy waste is estimated to be completed by about 2130 and it is currently assumed that disposal of new build wastes would begin once disposal of legacy wastes is completed. This assumes that new build ILW is disposed of to the same facility as the UK legacy waste inventory which would require agreement with the host community through the MRWS process as described in Section 6.8 of this chapter.

6.36.2 The proposed decommissioning strategy which would be employed at HPC is Early Site Clearance. Fundamentally the strategy means that decommissioning would commence as soon as possible after End of Generation at the site, and would proceed without significant delay to complete the process of decommissioning of the reactors and auxiliary buildings. Therefore a reactor that begins generation in 2017, with a 60 year generating life, could have all ILW packaged and ready for transfer to GDF by approximately 2090 i.e. significantly earlier than the current assumption regarding availability of the GDF.

6.36.3 The current scheduling for transfer of waste to the GDF has been devised by NDA based on a design which has not been optimised for new build waste. Optimisation of the current scheduling programme for legacy ILW could allow disposal of new build ILW on earlier time scales than currently assumed. NDA is engaging with nuclear new build operators to determine whether it is feasible to establish an optimised baseline which would allow earlier disposal of ILW to the GDF.

6.36.4 For the purposes of decommissioning planning it is assumed that the GDF scheduling can be optimised to allow transfer of packaged ILW during the main site decommissioning phase. However if optimisation requires a further period of interim storage it is possible that the storage facility may need refurbishment to extend its life until the GDF is available. Safety issues related to the design of the storage facility and the extension of its life would be regulated outside of the planning regime, through nuclear site licensing.

6.36.5 The potential impact of the disposal of UK EPR operational and decommissioning ILW on the size of a GDF has been assessed by NDA RWMD. Although the impact depends to some extent on the type of package, it has been concluded that in all cases the volume increase is relatively small, corresponding to less than approximately 60m of disposal vault length for each UK EPR. This represents less than 1% of the area required for the UK legacy ILW, per reactor (Ref. 6.17).

6.37 Potential Impacts of ILW Management Activities

6.37.1 The potential impacts associated with the ILW management activities proposed at HPC have been considered as part of the HPC construction and operational assessments within the specific chapters of this volume. Table 6.37.1 identifies the high level impacts and provides a link to the chapters where the impacts of construction, operation and decommissioning of ILW management facilities are covered in greater detail.

Table 6.37.1: Potential Adverse Effects of ILW Management Activities

Activity	Impact	Volume/Chapter
Processing of ILW for off-site transfer	The processing of ILW in preparation for interim storage and eventual disposal to the GDF would take place within purpose built facilities. These processes would result in discharges of radioactivity which would represent a small proportion of the HPC site total radioactive discharges. The impact of HPC radiological discharges is considered within the 'Radiological Impact Assessment' chapter of this volume.	Volume 2 Chapter 20
Interim storage of ILW	The interim storage of ILW prior to transfer and disposal at the GDF would take place within the purpose built ILW Interim Storage Facility. The store would be required to be compliant with the Nuclear Site License and RSR permit with regard to radiological safety and discharges and as such the impacts would be carefully controlled and minimised through ALARP and BAT. The implications of direct dose and discharges from HPC are considered in the 'Radiological Impact Assessment' chapter of this volume.	Volume 2 Chapter 20
Construction of ILW management facilities	The construction of the ILW processing and storage facilities would be part of the main on-site construction activities. The impact of construction activities at HPC is considered within the 'Construction of Hinkley Point C' chapter of this volume.	Volume 2 Chapter 3
Transport of ILW to off-site GDF	Transport of ILW from HPC for off-site disposal to a GDF is not anticipated to take place until the End of Generation (indicatively 2080). The impact of transportation of waste during this period is identified within the 'Decommissioning of Hinkley Point C' chapter of this volume.	Volume 2 Chapter 5
Decommissioning of ILW management facilities	The decommissioning of the ILW Interim Storage Facility would only take place when all operational ILW has been transferred from HPC. Impacts regarding the decommissioning of the ILW management facilities are considered in the 'Decommissioning of Hinkley Point C' Chapter of this volume.	Volume 2 Chapter 5

6.38 Management of Spent Fuel Generated during the Operation of HPC UK EPRs

6.38.1 The UK EPR core contains the nuclear fuel in which the fission reaction occurs. The remainder of the active core structure serves either to support the fuel, control the chain reaction or to channel the coolant.

6.38.2 The reactor core of a UK EPR would typically consist of 241 fuel assemblies providing a controlled fission reaction and a heat source for electrical power production. Each fuel assembly is formed by a 17×17 array of Zircaloy M5 tubes, made up of 265 fuel rods and 24 guide thimbles. The fuel rods consist of uranium dioxide pellets stacked in a Zircaloy M5 cladding tube which is then plugged and seal welded (Ref. 6.17).

6.38.3 A maximum of 90 spent fuel assemblies (SFA) would be removed every 18 months of operation from each EPR. With time included for planned outages for maintenance over the anticipated 60 years operation, a total of approximately 3,400 assemblies per EPR are expected to be generated. Through the lifetime of HPC, which would have two EPRs, a total of around 6,800 fuel assemblies would be generated.

6.38.4 The dimensions of one fuel assembly are 0.214m x 0.214m x 4.805m so the raw waste volume associated with the lifetime total of 6,800 fuel assemblies requiring interim on-site storage would be 1,496 m^3. Each spent fuel assembly has a mass of 527.5 kg of uranium; therefore a total inventory at End of Generation would be approximately 3600 tonnes.

6.39 Requirement for Interim On-Site Storage of Spent Fuel

6.39.1 As stated in paragraph 6.4.2 of this chapter the 2008 Government White Paper, Meeting the Energy Challenge A White Paper on Nuclear Power (Ref. 6.3) concluded that in the absence of any proposals from industry (for reprocessing) any new nuclear power stations that might be built in the UK should proceed on the basis that spent fuel would not be reprocessed and that plans for, and financing of, waste management should proceed on this basis.

6.39.2 Whilst there is a Government programme in place to develop a geological GDF, there is currently no disposal facility for spent fuel and the GDF is not expected to be available when the HPC EPRs start generating spent fuel. The strategy for spent fuel management at HPC is, therefore, to store the spent fuel on-site pending availability of a GDF. Although it is possible that, over the life of the station alternative facilities could become available that might allow spent fuel to be transported offsite, it is prudent to plan on the basis that sufficient capacity is provided on-site to store the lifetime arisings of spent fuel from the two EPRs.

6.40 Importance of Interim Storage for Spent Fuel

6.40.1 Spent fuel is highly radioactive when it is removed from the reactor. All radioactive materials eventually become non-radioactive but while some lose their radioactivity within fractions of a second, others take many thousands of years. The radioactivity of spent nuclear fuel falls to about one hundredth of its original level within a year and to one thousandth of its original level within 40 years. The high level of radioactivity concentrated within spent fuel results in a significant level of heat being produced. This characteristic makes a period of interim storage, during which the level of heat production reduces, an important element of spent fuel management ahead of its eventual disposal.

6.41 Arrangements for Site Spent Fuel Management

6.41.1 Heat generated through the process by which the radioactive atoms within the spent fuel eventually become non-radioactive (called “radioactive decay”) means that spent fuel removed from a reactor must be cooled for an initial period before it can be placed into interim storage. For the UK EPR, fuel assemblies removed from the reactor would be cooled underwater in a reactor fuel pond for up to 10 years; indicatively the storage period in the reactor fuel pond is only a few years. The reactor fuel ponds are not designed for the full life-time arisings of spent fuel.

6.41.2 Following this initial storage period in the reactor fuel pond, the spent fuel assemblies would be prepared for transfer to the separate spent fuel Interim Storage Facility (spent fuel ISF) where they can be safely stored until a UK GDF is available for transfer and the spent fuel is ready for final disposal.

6.42 Spent Fuel Interim Storage at HPC

6.42.1 The spent fuel ISF would provide storage for spent fuel from the HPC UK EPRs from around 10 years after the first unit’s start up until the spent fuel is shipped off-site for disposal at the GDF. The ISF would be designed such that its life can be extended to last for up to 100 years following the end of reactor operations if required through refurbishment or replacement. This would allow interim storage to be maintained until a GDF, or an alternative disposal/management route, has been established and the heat levels within the fuel are at levels that permit its disposal.

6.42.2 The design of the spent fuel ISF must be capable of meeting the following requirements:

- to ensure safe operations (e.g. by preventing a criticality incident and maintaining effective containment);
- to provide radiological protection to the public, workers and the environment at all times in compliance with dose limits and ensuring that all doses are ALARP and discharges to the environment are demonstrated to be minimised in accordance with BAT;
- to ensure cooling to maintain spent fuel integrity; and
- to maintain spent fuel in a condition appropriate for transport and final disposal.

6.42.3 EDF Energy has reviewed the options available for on-site interim storage of spent fuel and determined that for the site specific circumstances at HPC, wet interim storage within an engineered pool or pond is the preferred approach. The alternative technical options that have been considered and the factors leading to EDF Energy's choice of preferred option are identified within Chapter 6 Volume 1.

6.42.4 Wet storage of spent fuel has been used widely in the UK and internationally and has been licensed previously. It is considered to be both safe and environmentally acceptable for use in the UK for spent fuel generated from operation of HPC. The use of wet interim storage of spent fuel is capable of providing HPC with a safe, secure and technically flexible solution until such time that the spent fuel is suitable for transfer and a UK GDF, or other off-site management facility, is available.

6.43 Key Safety and Operational Features Associated with the HPC Spent Fuel ISF

6.43.1 The spent fuel ISF would have a range of safety features to maintain the safety of spent fuel. The design and operation of the facility would be required to be compliant with the Nuclear Site Licence with regard to the safety of workers and the public.

6.43.2 A brief outline of the key safety features of wet storage is set out below:

- the significant water volume within the pond provides a variety of safety functions. It would slow down the rate of any water temperature increase and reduce the significance of any loss of water so that the water make-up system would easily maintain the water level in the event of losses. In the highly unlikely case of a total loss of the pond cooling there is a lengthy 'grace period' before evaporation of the water could lead to fuel uncovering which would allow the operator time to react to put the installation in a safe state; the water volume also provides a 'shielding' barrier that significantly reduces radiation levels for operators; and in the event there were any radioactivity release from within the fuel the water provides a medium within which the activity can be held up and ultimately removed so mitigating any release into the environment;
- the facility would be designed to be resistant to movement by events such as earthquakes and other external events;
- the spent fuel pond would be equipped with cooling systems (i.e. pumps and heat exchangers);
- clean-up systems are also provided to maintain water quality and the water chemistry is controlled to minimise corrosion of fuel assemblies;
- the spent fuel pond would be designed with appropriate containment systems and have leak detection and collection systems;
- wet storage allows the monitoring of water parameters (temperature, radioactivity, pH and chemical composition) and ventilation parameters. These features permit the rapid detection of changes and therefore allow mitigation measures to be implemented if required; and
- the assemblies in wet storage would be accessible and the storage area visible. The water would provide effective shielding against radiation emitted by the spent fuel. Thus spent fuel inspection in wet storage would therefore be possible without retrieval.

6.43.3 It was determined that for the specific requirements of HPC wet storage has a number of key positive operational features with regard to technical performance, operability, and flexibility.

6.43.4 A brief outline of the key operational features is set out below:

- the effective cooling provided by the spent fuel pond storage system leads to high confidence that the levels of heat generation within the current, and potential future types of, EPR spent fuel that could be utilised over the lifetime of the station would be accommodated;

- for the same reason, the wet storage facility is flexible to changes in residual thermal power of the stored assemblies that could arise with possible future increases in EPR fuel burn-up or fuel composition;
- the assemblies would be retrievable and suitable for subsequent transport after potentially long periods of interim storage. The facility storage environment can be adapted to ensure that the spent fuel would be compatible with the GDF requirements as these develop further;
- wet storage allows flexibility in selecting the assemblies to be retrieved for transport. It is possible when employing the wet storage concept to combine assemblies with lower and higher residual thermal energies (older and newer assemblies respectively) after storage in the ISF to optimise the packages produced for the purposes of retrieval and permanent storage at the GDF, allowing for greater flexibility in spent fuel management; and
- the ease of inspection and monitoring means that should assemblies be damaged during storage, such assemblies would be detected rapidly and managed to mitigate any impact on workers or discharges.

6.44 Facilities for On-Site Spent Fuel Storage

6.44.1 The HPC spent fuel ISF facility can be broken down into a number of functional processes:

- fuel would be removed from reactor fuel pool and packaged into transport cask for transfer to the separate spent fuel ISF;
- on arrival at the spent fuel ISF, spent fuel would be removed from the transfer flask underwater;
- the flask lid would be opened and the flask prepared for unloading;
- the fuel assemblies are unloaded one at a time and placed into storage racks;
- pond handling equipment would be used:
  - to remove fuel from a storage rack;
  - to move the racks from the loading position to the storage positions in the pond;
  - to move the racks during storage to optimise pond loading;
  - to move the racks from/to the stored position to permit fuel inspection; and
  - to move the racks from the stored positions to the unloading position (at the end of the interim storage period);
- throughout the operational life of the spent fuel ISF an inspection and monitoring regime would be implemented to ensure that fuel is stored safely;
- spent fuel would not be placed into storage within the spent fuel ISF until several years after the start of generation. The minimisation of waste and discharges from spent fuel ISF operations, through the application of Best Available Techniques (BAT), would therefore be able to take into account experience from storing fuel assemblies in the reactor building pond as part of reactor operations; and
- at the end of interim storage the SFAs would be loaded into transport flasks for transfer to a packaging plant to allow disposal to a GDF.

6.45 Management of Radioactive Waste and Discharges from the Spent Fuel ISF

6.45.1 Wet interim storage would result in the generation of small quantities of liquid, gaseous and solid radioactive wastes resulting from the requirement to maintain pool water quality, to ensure that doses to workers are as low as reasonably practicable (ALARP), and to minimise discharges of radioactivity to the environment. These wastes would require management throughout the lifetime of the interim store.

6.45.2 The minimisation of wastes and discharges from spent fuel ISF operations, through the application of BAT, would need to be demonstrated in order for EDF Energy to fulfil the requirements of the RSR Environmental Permit.

6.45.3 It is anticipated that liquid discharges from the spent fuel ISF would be routed to the same discharge point as for other liquid discharges from both HPC UK EPRs. The first preliminary studies indicate that the liquid discharges from the spent fuel ISF would be minor in comparison to the already small radioactive liquid discharges from the operation of both UK EPRs. It is anticipated that the gaseous releases of the spent fuel ISF would be discharged by a specific stack on the spent fuel ISF. Again, the gaseous discharges associated with spent fuel management would be much less than the already very small gaseous discharges associated with the UK EPRs themselves.

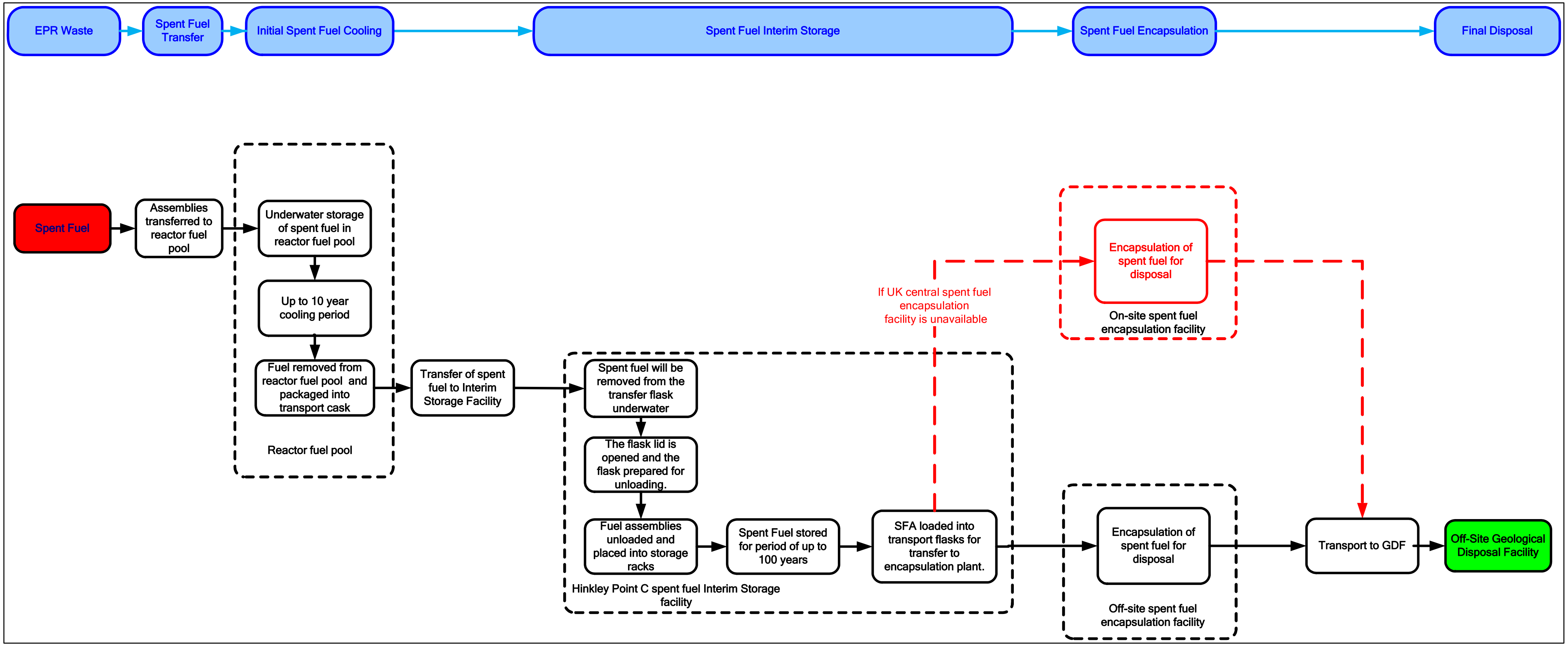
6.45.4 It is anticipated that the treatment of any radioactive waste generated from operation of the spent fuel ISF during the period of reactor operations would be carried out in the ETB. Waste generated following the decommissioning of the reactor site and auxiliary buildings would require management within a new waste treatment building. It is anticipated that these wastes would be transferred for disposal directly to GDF in the case of ILW, or to a suitable LLW disposal facility for LLW, without the need for interim storage on-site. In the event that disposal facilities are unavailable following decommissioning of the reactor site and auxiliary buildings an additional period of on-site interim storage for the ILW and LLW from spent fuel management may be required.

6.46 Spent Fuel Management Following Reactor Decommissioning

6.46.1 At the End of Generation (indicatively 2077 for unit 1 and 2080 for unit 2) all remaining spent fuel would be removed from the reactors and transferred to the spent fuel ISF, following the initial cooling period in the reactor storage pools. During the main site decommissioning phase the spent fuel would continue to be stored in the on-site interim store and the store would be modified to allow it to be a stand alone facility after the rest of the site has been decommissioned.

6.46.2 Following the end of the main site decommissioning the spent fuel would remain within the spent fuel ISF. The facility would continue to be licensed and would include the provision of a number of additional facilities to accommodate the requirements for a small workforce to operate the storage facility, ensure security of the site, and maintain the continuation of all safety and environmental obligations. The costs for these modifications and the operation would be funded by the EDF Energy FDP. **Figure 6.46.1** sets out the proposed spent fuel management baseline. Only when all the spent fuel has been removed from the spent fuel ISF, and decommissioning of the facility is completed, would this remaining part of the site be de-licensed and the land released for alternative use.

Figure 6.46.1: HPC Spent Fuel Management Strategy



6.47 Timing of Transfer of Spent Fuel to GDF

6.47.1 The time that would be required for the safe and secure on-site interim storage of spent fuel prior to disposal depends on a number of factors.

6.47.2 NDA's disposability assessment for UK EPR spent fuel included the finding that if spent fuel is produced at the highest burn-up considered (65 GWd/tU), spent fuel cooling (i.e. the time in interim storage) might be required for a period of up to 100 years before disposal to GDF (Ref. 6.17). It is acknowledged that this figure is conservative and may be reduced as a result of further work.

6.47.3 Therefore it is possible that the HPC spent fuel ISF might be needed for 100 years after the End of Generation, to enable an adequate cooling period for the last fuel to be removed from the reactor.

6.47.4 This means that in the case of a HPC UK EPR commencing operation in 2017 with an operational life of 60 years, the last fuel removed from the reactor would be at End of Generation (in 2077). Consequently, if this fuel were required to be stored for 100 years before it could be accepted for disposal, it would not be removed from the spent fuel ISF until 2177.

6.48 Alternative Scenarios for Long Term Interim Storage of Spent Fuel

6.48.1 The scenario above is considered to represent the bounding case, when assuming an operating life of 60 years, which would result in spent fuel remaining on the HPC site in on-site interim storage for the longest period of time.

6.48.2 There are a number of alternative scenarios which could result in spent fuel being transferred from the site significantly earlier therefore allowing earlier decommissioning of the spent fuel ISF and subsequent site de-licensing. For example:

- the provision of a UK centralised spent fuel interim storage facility;
- a change which resulted in reprocessing becoming a more preferable approach during the lifetime of the spent fuel ISF;
- a reduction in pessimisms in the 100 year cooling assessment; or
- the optimisation of the GDF design to better accommodate new build spent fuel.

6.48.3 The NDA is engaging with potential new build operators, including EDF Energy, to undertake feasibility studies to investigate several key issues associated with spent fuel management and disposal. It is intended that the feasibility studies would provide a better understanding of the issues and provide a basis for future decision-making on whether the current baseline disposal concept can be optimised.

6.49 Packaging (Encapsulation) of Spent Fuel for Disposal

6.49.1 The Radioactive Waste Management Directorate (RWMD) is developing disposal concepts for HLW and spent fuel undertaking work on several related areas.

6.49.2 In relation to disposal, RWMD has developed a reference concept based on the Swedish KBS-3V method. This concept is known as the UK Reference HLW and Spent Fuel Repository Concept.

The concept was developed in order to demonstrate the viability of geological disposal of HLW and spent fuel in the UK.

6.49.3 Under this concept, spent fuel would be over-packed before disposal into durable, corrosion resistant disposal canisters manufactured from suitable materials, which would provide long term containment for the radionuclides contained within the spent fuel. This process is known as encapsulation.

6.49.4 There are two basic options for encapsulation of spent fuel:

- packaging into disposal containers at the nuclear power station site; or
- packaging into disposal containers at a central location.

6.49.5 The baseline assumption used in EDF Energy's decommissioning and waste management planning is that the encapsulation of spent fuel into disposal containers would take place at an off-site central facility. As the store is emptied, the spent fuel would be packaged into suitable transport containers for transfer to a central national encapsulation facility. Retrieval operations to enable transport to allow for despatch to an encapsulation plant would consist of taking out the spent fuel from the spent fuel ISF and loading it in a transportation cask.

6.49.6 In the event that a national, or regional, facility for encapsulation of spent fuel is unavailable at the time of store emptying, it is possible that encapsulation into disposal containers could occur on-site at HPC. This would require the construction of a new facility to undertake the process. The facility and operations would be required to be compliant with the NSL and RSR permit with regard to safety and radioactive waste discharges.

6.50 Transport and Disposal of Spent Fuel to GDF

6.50.1 RWMD has undertaken, as part of the guideline daily amounts (GDA) of the UK EPR, a Disposability Assessment for the spent fuel expected to arise from the operation of a UK EPR (Ref. 6.17). This assessed the implications of the disposal of the proposed spent fuel disposal packages against the waste package standards and specifications developed by RWMD and the supporting safety assessments for a GDF. The safety of transport operations, handling and emplacement at a GDF, and the longer term performance of the system have been considered, together with the implications for the size and design of a GDF.

6.50.2 RWMD has concluded that spent fuel from operation of a UK EPR should be compatible with plans for transport and geological disposal of legacy spent fuel.

6.50.3 On the basis of the GDA Disposability Assessment for the UK EPR, RWMD has concluded that, compared with existing spent fuel, no new issues arise that challenge the fundamental disposability of the spent fuel expected to arise from operation of such a reactor. This conclusion is supported by the similarity of the fuel to that expected to arise from the existing PWR at Sizewell B. Given a disposal site with suitable characteristics, the spent fuel from the UK EPR is expected to be disposable.

6.50.4 The assumed operating scenario for a single UK EPR (60 years operation) gives rise to an estimated 900 disposal canisters. This has been calculated to require an area below ground of approximately 0.15km^2 for the associated disposal tunnels representing approximately 8% of the area required for legacy HLW and spent fuel (Ref. 6.17). The spent fuel associated with the two HPC UK EPRs would require an area of approximately 0.30km^2, excluding associated service facilities. This represents approximately 16% of the area required for legacy HLW and spent fuel.

6.51 Potential Impacts of Spent Fuel Management Activities

6.51.1 The potential impacts associated with spent fuel management activities proposed at HPC have been considered as part of the HPC construction and operational assessments within the specific chapters of this volume. **Table 6.51.1** identifies where the potential impact of construction, operation and decommissioning of the spent fuel management facilities are covered in greater detail.

Table 6.51.1: Potential Adverse Effects of Spent Fuel Management Activities

Activity	Impact	Volume/Chapter
Interim storage of spent fuel	The interim storage of spent fuel prior to transfer and disposal at the GDF would take place within the purpose built spent fuel Interim Storage Facility. The store would be required to be compliant with the Nuclear Site License and RSR permit with regard to radiological safety and discharges and as such the impacts would be carefully controlled and minimised through ALARP and BAT. The implications of direct dose and discharges from HPC are considered in the 'Radiological Impact Assessment' chapter of this volume.	Volume 2 Chapter 20
Construction of spent fuel management facilities	Construction of Facilities associated with spent fuel management would be part of the main on-site construction activities. The impact of construction activities at HPC is considered within the 'Construction of Hinkley Point C' chapter of this volume.	Volume 2 Chapter 3
Transport of spent fuel for encapsulation and disposal	Transport of spent fuel from HPC for off-site disposal to a GDF would not take place until well after the End of Generation at HPC (note: due to the current assumptions associated with the design of the GDF it has been conservatively assumed that fuel would require storage for approximately 100 years after removal from the reactor). The impact of transportation of waste during this period is identified within the 'Decommissioning of Hinkley Point C' chapter of this volume.	Volume 2 Chapter 5
Decommissioning of spent fuel management facilities	The decommissioning of the spent fuel Interim Storage Facility would only take place when all operational spent fuel has been transferred from HPC. Impacts regarding the decommissioning of the spent fuel management facilities are considered in the 'Decommissioning of Hinkley Point C' Chapter of this volume.	Volume 2 Chapter 5

6.52 Solid Radioactive Waste and Spent Fuel Management Overview

6.52.1 Generation of all radioactive solid wastes would be minimised through the application of the Waste Hierarchy and BAT to demonstrate environmental optimisation. The strategy for solid wastes generated at HPC is that they are to be disposed of as soon as practicable where an appropriate disposal route is available.

6.52.2 ILW and spent fuel for which there are no available disposal routes would be accumulated and safely stored on-site in compliance with the requirements of the NSL and RSR Environmental Permit until a suitable disposal route or an alternative management route becomes available.

6.52.3 Solid radioactive waste generated during operation of the HPC EPRs is expected to leave the site by one of the following routes:

- treatment of metals, ultimately for recycling, via commercially available routes subject to meeting the relevant CfA;
- incineration of combustible wastes using commercially available routes subject to meeting relevant CfA. There would be no on-site incineration of wastes;
- use of an appropriate authorised disposal facility for exempt and VLLW disposal (notably for soil, rubble and aggregates) where no reuse or recycling options are viable, subject to meeting relevant CfA;
- disposal of LLW at LLWR where the above alternatives are not viable;
- on site storage of ILW and spent fuel pending the availability of a Geological Disposal Facility.

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