Guidance on Requirements for Release of Nuclear Sites from Radioactive Substances Regulation

Consultation Document February 2016

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Preface and Summary

1. Preface to the guidance

1.1 About the environment agencies and this guidance

1.1.1 The Scottish Environment Protection Agency (SEPA), the Environment Agency (EA) and Natural Resources Wales (NRW) are responsible for regulating the disposal of radioactive waste on and from nuclear sites in Scotland, England and Wales respectively. For simplicity, we have used the terms 'the environment agencies' and 'we', 'us', or 'our' throughout this document when we refer to these organisations collectively.

1.1.2 The Radioactive Substances Act 1993 (RSA 93; HMSO 1993) in Scotland, and the Environmental Permitting Regulations 2010 (EPR 10; HMSO 2010) in England and Wales, give us legal powers and duties to authorise the disposal of radioactive waste. When we grant authorisations, we include limitations and conditions to protect people and the environment from the hazards presented by radioactive waste.

1.1.3 Changes to legislation in Scotland over the next few years will mean that RSA 93 will be replaced in Scotland by new regulations made under the Regulatory Reform (Scotland) Act 2014 (HMSO 2014). The new regulations will include provisions broadly similar to those of RSA 93 but are likely to provide further clarification of SEPA's powers for the regulation of nuclear sites. In addition a common framework for environmental permitting across different environmental regulatory regimes is being adopted in Scotland (a common framework already exists in England and Wales under EPR 10).

1.1.4 Different terminology is used in RSA 93 and EPR 2010. For example, a document defining the conditions and limitations that an operator must comply with when disposing of radioactive waste is termed an 'authorisation' under RSA 93, and a 'permit' under EPR 2010. This guidance uses the term 'authorise', when describing the act of authorising or permitting a disposal and 'permit' when referring to the document that defines the conditions and limitations that an operator must comply with. Similarly, under RSA 93 an authorisation may be 'revoked', while under EPR 2010 a permit may be 'revoked' or 'surrendered'. This guidance uses the phrase 'release from radioactive substances regulation (RSR)' to describe the act of revoking or surrendering an authorisation or permit.

1.1.5 This guidance is intended principally for the operators of proposed or existing nuclear sites. It explains the requirements that we expect operators to fulfil when developing their plans for the management of radioactive waste and when demonstrating, through a site wide environmental safety case, how those plans will leave their site in a state that is suitable for release from RSR.

1.2 Plain English

1.2.1 Our main audience, the operators of nuclear sites, is a specialist one. We need to make our requirements as clear and unambiguous as possible for them. This guidance therefore contains many specialist terms that have a precise meaning. We recognise that this may make the document less accessible to a wider audience, but we have tried to overcome this difficulty as far as possible. In particular, we have provided an introductory section to each chapter, so that everyone can understand what the chapter is about. We have also included a glossary of significant specialist terms.

1.3 Background to this guidance

1.3.1 There are many nuclear sites in Great Britain that are currently undergoing decommissioning and clean up. Although in some cases it will be many years before all this work is completed, decisions are needed now about the level of clean-up required and whether to leave some radioactive waste in situ. This guidance provides a set of requirements to enable site operators to make the decisions they need to bring a site to a state in which it can then be made available for other uses, and eventually released from RSR for unrestricted use.

1.3.2 The proposed guidance aims to provide a common standard that can be applied to all nuclear sites throughout Great Britain, to enable them to be released from RSR. It seeks to provide a clear explanation of what the environment agencies expect a nuclear site operator to do to demonstrate that all necessary work on site involving radioactive waste has been completed and that the public and the environment will be adequately protected.

1.3.3 The proposed guidance applies to all types of nuclear sites at all stages of their lifecycles. This has been achieved by ensuring that optimisation and a proportionate approach lie at the heart of the requirements and process for releasing a site from RSR.

2. Stakeholder summary

2.1.1 The Environment Agency, Natural Resources Wales, and the Scottish Environment Protection Agency (the environment agencies) are the environmental regulators for England, Wales and Scotland, respectively. Our responsibilities include regulating the disposal of radioactive waste on or from nuclear sites, so that the health of people and the integrity of the environment are protected. All disposals of radioactive waste must comply with conditions and limits set out in permits granted by the relevant environment agency.

2.1.2 Throughout Great Britain, many nuclear sites are being decommissioned and cleaned up. Eventually, an operator will wish to apply to the relevant environment agency for all, or part, of a site to be released from radioactive substances regulation. The environment agencies will only agree to release a nuclear site from our regulation if we are satisfied that radioactive waste disposal has ended and that the site is in a state that will ensure a satisfactory standard of protection for people and the environment.

2.1.3 Past operations at nuclear sites have produced large amounts of radioactive waste. Decommissioning will result in greater amounts, as facilities contaminated by radioactivity are dismantled and demolished. Buried structures, such as foundations, drains and pipes, if they are sufficiently contaminated, will become radioactive waste once they are no longer in use. Although areas of undisturbed ground or groundwater contaminated by radioactivity are not themselves radioactive waste, their clean-up may produce radioactive waste.

2.1.4 In regulating radioactive waste disposal, the environment agencies are obliged, by international and domestic standards and law, to ensure that exposures of people to radiation are kept below certain limits and constraints.

2.1.5 Moreover, below these limits and constraints, exposures must be kept as low as reasonably achievable, taking account of economic and societal factors. This is referred to as optimisation, an essential principle in radiological protection. Optimisation should seek to keep the radiological exposure of people as low as possible, consistent with keeping the detriments (environmental, societal, economic, etc.) of managing that exposure at acceptable levels.

2.1.6 This consideration of many factors means that a process of optimisation should ensure a suitably low level of risk from radiological exposure, but does not necessarily require the lowest possible risk. Applying optimisation to nuclear site decommissioning and clean-up should ensure that radioactive waste and contamination are managed in a way that is safe, but may not necessarily lead to all radioactivity being removed from a site.

2.1.7 Operators of different nuclear sites may therefore make different decisions about the amounts and types of radioactive waste or contamination they propose to remove for disposal at facilities elsewhere, or to leave on or adjacent to their site.

2.1.8 However, the primary objective must be the satisfactory protection of people and the environment. That is why the environment agencies have published this guidance document, to explain the principles, requirements and regulatory process we will apply to nuclear sites in all stages of decommissioning and clean-up. Our aim is to ensure that radioactive waste and contamination is managed in a way that is safe, and that strikes an appropriate balance between human health, environmental,

societal, economic and other relevant factors, so that nuclear sites may eventually be released from regulation under radioactive substance legislation.

2.1.9 Part 1 of the guidance describes the environment agencies' principles for protection of people and the environment from radioactivity remaining on or adjacent to nuclear sites.

2.1.10 Part 2 of the guidance sets out the environment agencies' detailed requirements which, if met in full by an operator, will satisfy our principles.

2.1.11 Part 3 of the guidance describes how we expect an operator to implement our requirements over the lifetime of a site, and, ultimately, satisfy the relevant environment agency that a site can be released from radioactive substances regulation.

3. Introduction to the Guidance

3.1 Introduction

3.1.1 In this document we describe what the operator of a nuclear site needs to do over the lifetime of a site, so that the site can be released from radioactive substances regulation (RSR)[1] when all activities involving the generation and disposal of radioactive waste have ceased. We specify the condition of the site to be achieved and how the operator should achieve that condition. We have done this through a fundamental protection objective, a set of principles, and more detailed requirements describing how the objective and principles should be met. This is largely a risk-based approach.

3.1.2 In this chapter we present an overview of our approach to the release of nuclear sites from RSR. Chapters 4 and 5 set out the standards to be achieved both before and after the release from regulation. Chapters 6 and 7 describe how the operator demonstrates that these standards are being met and how the associated programme of waste disposals is being managed. Chapter 8 covers associated regulatory requirements on operators under their permits during the lifetime of the facility leading to release from regulation.

3.1.3 Operators need to read and apply this guidance within a wider context. This includes:

- all relevant environmental legislation;
- relevant Government policy, in particular the policy statement *The decommissioning of the UK Nuclear Industry's Facilities* (UK Government and the Devolved Administrations 2004)
- other RSR guidance

3.1.4 We expect **all** the requirements set out in this guidance to be met in a manner proportionate to the radiological, and any associated non-radiological, hazards that the operator's decommissioning and clean-up plans are intended to reduce or remove, and to any such hazards that remain on or adjacent to the site when all planned operations are complete.

3.2 Our standards

3.2.1 Our fundamental protection objective is "*to ensure that a nuclear site is brought to a condition at which it can be released from radioactive substances regulation, through a process which protects the health and interests of people and the integrity of the environment both during the period of regulation and afterwards, and which inspires public confidence and takes account of costs*". We specify that condition through Principles 1 and 3 and through Requirements R7, R8, R9 and R10.

3.2.2 The operator should bring the site to a condition at which it can be released from radioactive substances regulation *"through a process that will keep the radiological risks to individual members of the public and the population as a whole as low as reasonably achievable (ALARA) throughout the period of regulation and afterwards, as far as can be judged at the time when relevant actions are taken. Such optimisation shall take into account economic and societal factors and the need to*

[1] "Release from regulation" means either surrender of the permit under EPR10 in England and Wales, or revocation of an RSA93 authorisation in Scotland.

manage radiological risks to other living organisms and any associated non-radiological hazards".

3.2.3 This is the optimisation requirement (Requirement R10) which flows directly from our optimisation principle (Principle 2). "Optimisation" is a main principle and requirement determining the residual levels of activity that may be acceptable to remain on site after completion of all work involving radioactive substances, subject to meeting other relevant requirements, such as R7 (risk guidance level) and R8 (human intrusion dose guidance level). For the avoidance of doubt, an "inventory-based" approach, which is focused only on assessing the amount of residual activity consistent with requirements R7 and R8, is not acceptable, as it does not take account of optimisation.

3.2.4 Radioactive waste and contamination must be managed in a way that is safe, and optimised, so that nuclear sites may eventually be released from regulation under radioactive substance legislation.

3.3 Meeting our Standards

3.3.1 The actions necessary to bring a site to a condition at which it can be released from RSR are not limited to decommissioning sites. We expect the operators of new facilities to have regard from the outset to how they intend to design, build, operate and decommission the facilities so as to meet out standards for release of the site from RSR. We expect the operators of existing facilities to do the same at the earliest practicable opportunity. Operators should ensure the site is characterised before construction commences and that an appropriate WMP and SWESC are in place when applying for authorisation for any new facility.

3.3.2 Our permits require operators to minimise the amount of radioactive waste needing disposal and to avoid contamination of the site so as to minimise the extent and duration of work to bring the site to a condition at which it can be released from RSR. We have separate, general guidance on our requirements in relation to the management of the generation and disposal of waste; these requirements are not repeated in this guidance.

3.3.3 The operator will need to take into account a number of factors to determine the optimised process to bring the site to a condition where it can be released from RSR. In particular, the operator will need to consider how much radioactivity will remain on site at the end of all work involving radioactive substances, consistent with the site being capable of subsequent release from RSR. That radioactivity may be a combination of residual contamination remaining at the end of decommissioning and clean-up, and waste that has been authorised to be disposed of on site during operation, decommissioning and clean-up of the site. Such waste may have been disposed of by being emplaced in engineered disposal facilities, used for a purpose such as void filling, or deliberately left in situ permanently. This is illustrated in Figure 1.

3.3.4 An operator may dispose of waste from decommissioning and clean-up on site, including leaving waste in situ, provided that:

- this is shown to be the optimised disposal option;
- it is consistent with our standards, taking account of all waste and contamination intended to remain on or adjacent to the site; and

- the operator has obtained timely regulatory approval for the waste disposal concerned.

3.3.5 All such disposals will require authorisation under RSR and are subject to the normal requirements of RSR legislation.

3.3.6 The optimised approach may result in a site being in a condition at the end of decommissioning and clean-up that either

- immediately meets our standards for unrestricted use; or
- requires a period of restricted use to protect people and the environment until radioactive decay and other attenuation processes allow unrestricted use of the site.

3.3.7 This is illustrated in Figure 2. We use the term “site reference state” to refer to the condition in which a site is available for unrestricted use. Even if this state is achieved immediately on completion of all planned work, we anticipate there will be a minimum period before release from RSR for the purposes of validation monitoring (see R13). This is shown as the “earliest release” in Figure 2.

3.3.8 The extent of controls during any period of restricted use and their duration will depend on a number of issues, such as the amount of residual radioactivity and the potential for exposure in the accessible environment. Our general view is illustrated in Figure 3.

3.3.9 An operator wishing to rely on a period of restricted use will need to provide assurance that the controls proposed will be sufficient to meet the relevant requirements and that the arrangements for applying the controls can be relied on to be implemented as planned and maintained as long as necessary.. Such controls might take a variety of forms, such as RSR permits, local authority planning controls and other legal instruments. The existence of an RSR permit does not itself preclude use of the site for other purposes, but permit conditions might be used to provide appropriate controls.

3.3.10 The operator will need to assess and specify the required duration of any period of restricted use and the associated controls as part of the optimisation process. We are, however, unlikely to accept a claim for a period of restricted use of longer than 300 years from the end of planned operations, because of the major social changes that may take place over long periods of time.

3.3.11 An operator may seek release from RSR when the site reaches the site reference state as that is, by definition, when our standards are met without the need for restrictions or controls. This is shown as the latest surrender in Figure 2. Alternatively, an operator may seek earlier release by demonstrating that adequate controls will be put in place to ensure that our standards are met, and will continue to be met, without any reliance on controls under RSR. This is the period between earliest and latest surrender in Figure 2. The actual timing of release during this period will be site specific depending on when the operator applies for and successfully makes the case for release.

3.4 Demonstrating that our standards will be met

3.4.1 The operator will need to establish and maintain, as a condition of the RSR permit:

- a site-wide environmental safety case (SWESC) demonstrating that people and the environment are, and at all future times will continue to be, adequately protected from the radiological hazard and any non-radiological hazards associated with all the anthropogenic radioactivity (excluding background) remaining on or adjacent to the site; and
- a waste management plan (WMP) setting out the current intent for dealing with this anthropogenic radioactivity. The waste management plan (WMP) may be regarded as part of the wider decommissioning and clean-up plan for the site.

3.4.2 The operator should prepare the SWESC and WMP at the earliest practicable opportunity, and review and, where appropriate, revise them to maintain up to date documentation.

3.4.3 The operator will need to submit a WMP, supported by a SWESC, if applying for a variation to dispose of waste on-site, including leaving waste in situ. We encourage operators to make a single application based on their WMP for all planned waste disposals, recognising that may be subject to review and revision over time. We will only authorise the disposal of radioactive waste on site if the operator demonstrates, through the WMP and the SWESC, that such disposals are both safe and optimised. We will normally authorise all such disposals within the existing site permit. We may require a separate authorisation for a dedicated waste disposal facility, that is a facility subject to our *Near-surface disposal facilities on land for solid radioactive wastes: Guidance on requirements for authorisation* ("NS-GRA"; Environment Agency et al 2009.

3.4.4 The operator will need to provide a complete and up to date SWESC in support of an application for release from regulation. We will not release the site from regulation unless and until we are satisfied with the SWESC.

3.5 Article 37

3.5.1 Article 37 of the Euratom Treaty (European Atomic Energy Community 1957) specifies that each Member State shall submit to the European Commission such general data concerning any plan for the disposal of radioactive waste as will enable the Commission to give its opinion on whether the implementation of such a plan is liable to result in the radiological contamination (significant from the point of view of health) in another Member State. Relevant operations for consideration include "the emplacement of radioactive waste above or under the ground without the intention of retrieval". Thus, if the waste management plan (WMP) for a nuclear site contains a proposal to dispose of radioactive waste on site (including leaving radioactive waste in situ), the submission of general data under Article 37 must be considered. In most cases a submission of general data will be needed (unless it can be clearly demonstrated that Article 37 does not apply in a particular case). The UK Government's Department for Energy and Climate Change (DECC), on whom Article 37 places a duty, should be consulted should there be any doubt about the application of Article 37. Permitting any such disposal must await a positive decision on the Article 37 submission.

3.5.2 The dismantling of nuclear reactors, mixed oxide fuel fabrication plants and reprocessing plants requires an Article 37 submission. If proposals to dispose of radioactive waste on site are included in the Article 37 submission for such dismantling, a separate Article 37 submission for the WMP is not needed.

3.5.3 If the WMP for the site is revised such that the radiological consequences from unplanned releases in another Member State become greater than those assessed

in the original Article 37 submission, or the authorised limits or associated requirements become less restrictive, then an updated Article 37 submission is required and any permit variation needed to allow the revised WMP to be put into effect must await a positive decision on the updated Article 37 submission.

3.6 Other considerations

3.6.1 The principles and requirements in this guidance refer to radioactive contamination and radioactive waste; that is waste whose levels of radioactivity exceed the out of scope value in RSR legislation. This is explained further in Chapter 7 and in Figure 8. Our requirements include consideration of the chemotoxic properties associated with radioactive contamination and waste (Requirement R12) but do not directly extend to the chemotoxicity of, or any other hazards related to, non-radioactive contaminants and wastes on site. But we encourage operators to extend the WMP and the SWESC to consider all hazards on site, both radiological and non-radiological, so as to develop a single integrated approach that takes account of and meets all relevant regulatory expectations in relation to protection of people and the environment.

3.6.2 In particular operators should take an integrated approach to the management of the generation and disposal of wastes from contaminated structures, for example demolition wastes, to ensure that there is an integrated plan that best addresses all regulatory requirements. That plan should be in place before demolition commences.

3.6.3 Another consideration is the duty placed upon operators and the environment agencies to protect groundwater by Council Directive 2006/118/EC (EC 2006). It applies to all pollutants including radioactive substances. Guidance on the application of EC 2006 to radioactive substances and to other pollutants is provided for England and Wales by DEFRA (2011) and for Scotland by SEPA (2014).

3.7 The Office for Nuclear Regulation and the approach to de-licensing

3.7.1 The Office for Nuclear Regulation (ONR) regulates nuclear site safety and security under the Nuclear Installations Act 1965 (NIA 65), and is responsible for granting nuclear site licences to operators. ONR has provided guidance on nuclear site de-licensing on its website. There is currently no direct statutory link between release from RSR regulation and the ONR de-licensing process. Recognising that these are separate regulatory processes with separate requirements, the environment agencies have entered into Memoranda of Understanding with ONR, which set out a commitment to coordinate regulatory activities on nuclear licensed sites, to improve the effectiveness with which public sector resources are deployed and avoid the difficulties which might otherwise arise. The environment agencies are liaising with ONR in the development and implementation of this guidance, and will continue to do so in its implementation.

PART I: Fundamental Protection Objective and Principles

4. Fundamental protection objective and principles

4.1 Introduction

4.1.1 In this chapter we describe our fundamental protection objective, and five principles that will guide operators on how to achieve that objective during the decommissioning and clean-up of nuclear sites. We have chosen the fundamental protection objective and the principles as far as possible to be of an enduring nature.

4.1.2 The principles set out below lead on to the requirements in the next chapter of this document. The requirements are deliberately more specific than the principles, so that the operator can provide evidence that they have been met.

4.1.3 The environment agencies expect the requirements to be met in a manner proportionate to the radiological, and any associated non-radiological, hazards that:

- an operator's decommissioning and clean-up programme is intended to reduce or remove; and
- remain on or adjacent to a site when all planned operations involving radioactive substances are complete.

4.1.4 The principles recognise that decisions are based on the understanding and information available at the time the decisions are taken, and according to standards and accepted practices at that time.

4.2 Fundamental protection objective

4.2.1 **The fundamental protection objective is to ensure that a nuclear site is brought to a condition at which it can be released from radioactive substances regulation, through a process which protects the health and interests of people and the integrity of the environment both during the period of regulation and afterwards, and which inspires public confidence and takes account of costs.**

4.3 Principle 1: Level of protection against radiological hazards

4.3.1 **The site shall be brought to a condition at which it can be released from radioactive substances regulation, through a process that will provide protection to people and the environment, to the national standard applicable at the time when relevant actions are taken, against the radiological hazards during the period of regulation, and against any residual radiological hazards afterwards.**

4.3.2 This principle is consistent with the concept of intergenerational equity, including the availability of a clean environment to future generations. We can only judge what constitutes a clean environment according to present-day standards.

4.3.3 Radiological risks are not confined within national borders and may remain for a long time. When working out how to control radiation risks, the consequences, both now and in the future, of current actions have to be taken into account. In particular:

- safety standards not only apply locally, but also far from a site;

- where future generations could be affected, they are afforded the same level of protection as that applied at the time of surrender, without needing to take significant protective actions.

4.3.4 Measures are needed not only to protect people but also to protect the environment. The aim is to maintain biological diversity, conserve species, and protect the health and status of natural habitats and communities of living organisms. For non-human species the general intent is to protect ecosystems against radiation exposure that would have adverse consequences for a population as a whole, as distinct from protecting individual members of the population.

4.3.5 Where a standard of protection is numerical, the operator will need to carry out quantitative assessments to show conformity with it. This applies to, for example, the numerical standards of protection to people that are provided for the period of RSR by the dose constraints and after release from RSR by the risk guidance level and dose guidance levels for human intrusion.

4.3.6 Standards are continually being reviewed and protection standards may change with greater scientific understanding of the effects of radiation on human health and the environment. Such changes might lead to future revisions to the requirements set out in this document.

4.3.7 The International Committee on Radiological Protection (ICRP) provides recommendations and guidance on radiation protection. This principle (level of protection against radiological hazards) relates to the principle of optimisation of protection taken from ICRP's recommendations (ICRP 2007). The ICRP principle includes the statement that: "In order to avoid severely inequitable outcomes of this optimisation procedure, there should be restrictions on the doses or risks to individuals from a particular source (dose or risk reference levels and constraints)." The environment agencies have chosen to apply a risk guidance level (a reference level, see Requirement R7) rather than a risk constraint.

4.3.8 The environment agencies regard the advice from the International Atomic Energy Agency (IAEA) as a statement of good practice. This principle relates to IAEA Principle 6, *Limitation of risks to individuals*, taken from the IAEA's principles (IAEA 2006). The IAEA principle states that: "Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm." It also relates to IAEA Principle 7, *Protection of present and future generations* (IAEA 2006). The IAEA principle states that: "People and the environment, present and future, must be protected against radiation risks."

4.4 Principle 2: Optimisation (as low as reasonably achievable)

4.4.1 **The site shall be brought to a condition at which it can be released from radioactive substances regulation, through a process that will keep the radiological risks to individual members of the public and the population as a whole as low as reasonably achievable (ALARA) throughout the period of regulation and afterwards, as far as can be judged at the time when relevant actions are taken. Such optimisation shall take into account economic and societal factors and the need to manage radiological risks to other living organisms and any associated non-radiological hazards.**

4.4.2 This principle applies specifically to radiological risks to people in every situation where radiation could cause damage or harm. 'Optimisation' (keeping risks as low as reasonably achievable) applies only to radiological risks to people. Other living

organisms must also be protected from radiological hazards but there is no optimisation requirement. People and other living organisms must also be protected from non-radiological hazards, in compliance with applicable legislation and taking relevant guidance into account.

4.4.3 For decommissioning sites optimisation decisions will need to balance a number of competing risks to the public, workers and different geographically dispersed groups. The option to “do nothing” particularly in the case where a decision is made to leave radioactive waste in situ clearly has a consequential risk for people in the local area but avoids exposures to other groups.

4.4.4 Optimisation is a continuing, forward-looking and iterative process aimed at maximising the margin of benefit over harm. It takes into account both technical and socio-economic factors, and requires qualitative as well as quantitative judgements. It involves continually questioning whether everything reasonable has been done to reduce risks. In every organisation concerned, it requires commitment at all levels, together with adequate procedures and resources.

4.4.5 Optimisation decisions balance the detriment or harm associated with the radiological risk, together with other benefits and detriments (economic, human, societal, political, etc.) associated with the process of approaching and achieving the site reference state, both at the time the decisions are taken and in the future, and the resources available for protecting people and the environment. Optimisation decisions are constrained by the circumstances prevailing at the time. Optimisation needs to be viewed as part of a bigger picture, recognising that there will be competing claims for limited funds, and that nothing is completely risk free. The result of optimisation provides a radiological risk at a suitably low level, but not necessarily the option with the lowest possible radiological risk. The dose constraints and risk guidance level under Principle 1 are aimed at ensuring that the radiological risk is at a suitably low level.

4.5 Principle 3: Level of protection against non-radiological hazards

4.5.1 **The site shall be brought to a condition at which it can be released from radioactive substances regulation, through a process that will provide protection to people and the environment against any non-radiological hazards associated with the radiological hazards during the period of regulation, and against any such residual non-radiological hazards afterwards, to a level consistent with that provided by the national standard applicable at the time when relevant actions are taken.**

4.5.2 This principle recognises that there may be non-radiological hazards associated with radioactive substances remaining on or adjacent to a site, and that there needs to be an appropriate level of protection from these hazards. There are national standards for non-radiological hazardous substances. This principle does not require these standards necessarily to be applied, but requires a level of protection to be provided against these hazards that is consistent with the level of protection that would be provided if the standards were applied.

4.5.3 For example, radioactive wastes may contain residues of substances such as uranium and plutonium. These are heavy metals and as such are chemically toxic as well as being radioactive. Such wastes would present both a radiological and a non-radiological hazard. Non-radioactive substances containing residues of heavy metals such as mercury and lead, which present a non-radiological but not a radiological hazard, would be consigned to a specialised disposal facility for

hazardous waste, which must meet the national standards for such a facility. This principle does not ask for the specified national standards for non-radiological hazards to be applied, but asks for non-radiological hazards such as chemical toxicity to be taken into account when managing radioactive substances. Any suitable means can be used to protect against the non-radiological hazards, providing the protection against these hazards is as great as it would be if the wastes were not radioactive.

4.6 Principle 4: Reliance on human action

4.6.1 **The site shall be brought to a condition at which it can be released from radioactive substances regulation, in a manner such that unreasonable reliance on human action to protect people and the environment against radiological and any associated non-radiological hazards is avoided both before and after the site is released.**

4.6.2 Protection of the public and the environment may be provided through passive measures, i.e. measures that do not depend on human intervention, or by controls that rely on people. Protection may be confirmed by monitoring, which also relies on people. After any possible period of restricted use, the SWESC should not place reliance on controls that require future human actions.

4.7 Principle 5: Openness and inclusivity

4.7.1 **A process that is open and inclusive shall be used to bring the site to a condition at which it can be released from radioactive substances regulation.**

4.7.2 The relevant environment agency shall consult where appropriate and shall:

- establish ways of informing interested parties and the public about regulatory goals, processes and issues;
- consult in an open and inclusive way.

4.7.3 While carrying out our work, we shall seek to:

- Explain the basis for our regulatory decisions;
- Explain how we reach our judgements about the significance of uncertainties; and
- Provide an audit trail of regulatory decision-making.

4.7.4 We shall carry out our role in a proportionate way. For example, we shall involve stakeholders in considering significant changes but not necessarily consult separately about every individual issue.

4.7.5 Operators and other organisations will also need to work in a way that is consistent with this principle and our approach to ensure a fully open and inclusive process.

PART II: Requirements

5. Requirements: management, radiological and technical

5.1 Introduction

5.1.1 This part sets out the environment agencies' requirements for the operator to demonstrate that decommissioning and clean-up relating to radioactive substances, and any radioactivity remaining on a nuclear site after completion of this work, will not present an unacceptable risk to people and the environment, both during and after the period of radioactive substance regulation (RSR).

5.1.2 The operator will need to take account of **all** the requirements when managing the work to prepare a site for release from RSR. The operator will need to maintain a site wide environmental safety case (SWESC) showing that all the requirements have been met. The operator will also need to maintain a suitable waste management plan (WMP) to ensure that radioactive waste can be disposed of lawfully during the decommissioning and clean-up process. The SWESC and the WMP support one another, and the operator will need to maintain consistency between them.

5.1.3 Our requirements are set out below in three sub-sections; management, radiological and technical requirements.

5.2 Management requirements

Requirement R1. Early engagement

5.2.1 **The operator should engage as early as possible with the environmental regulator.**

5.2.2 We consider that early discussions will provide significant benefits for both the operator and us. Although we cannot provide regulatory certainty, discussions would help to ensure sufficient attention is focused on regulatory requirements in the early planning stages. In particular, we could comment on any proposals for on-site disposals, and on the potential suitability of decommissioning and clean-up projects and give early advice on possible environmental concerns.

5.2.3 Early discussions with us could also offer benefits to the operator under the land-use planning process; in particular, when considering what land-use planning conditions or controls over potential uses of the site that the relevant environment agency would recommend to the planning authority when consulted under the planning regime (also see Requirement R2).

5.2.4 Another advantage of early discussions is that we could publish our advice and comments on the operator's proposals for the site reference state. This would allow open discussion of the operator's proposals and the regulator's views with stakeholders such as local communities, other interested parties and the public.

Requirement R2. Engagement with local communities and others

5.2.5 **The operator should engage with the Office for Nuclear Regulation (ONR), planning authority, local community, other interested parties and the general public on its developing site wide environmental safety case (SWESC) and waste management plan (WMP).**

5.2.6 Generally, we expect the operator to engage widely in discussion of its plans to achieve the site reference state and its developing SWESC and WMP. The planning authority and local communities are likely to have an important role in any such discussions.

Requirement R3. Site Wide Environmental Safety Case

5.2.7 **The operator should maintain a site wide environmental safety case (SWESC) to demonstrate that people and the environment will be adequately protected, both before and after the site is released from radioactive substances regulation.**

5.2.8 The SWESC (see Glossary for definition) is a set of claims concerning the environmental safety of the nuclear site as a whole. It should address the present state and all envisaged future states of the site, both during the lifetime of the permit and during the indefinite period after the permit has been surrendered. The SWESC should consider all the relevant anthropogenic radioactivity remaining on and adjacent to the site, seeking to demonstrate that people and the environment will be protected from the radiological hazard and any non-radiological hazards associated with this radioactivity. The SWESC should consider evolution of the site without operator control in the period after the permit has been surrendered. The SWESC is closely linked to the waste management plan (WMP - see Requirement R4) and the operator should develop the SWESC and the WMP together, and maintain consistency between them.

5.2.9 The operator should maintain, and provide to the relevant environment agency when required, a SWESC that demonstrates conformity with the principles and each requirement set out in this document. It should be technically sound, but also proportionate, in terms of complexity and the level of detail it provides, to:

- the radiological and any associated non-radiological hazards that an operator's WMP is intended to reduce or remove; and
- the radiological hazards of anthropogenic origin and any associated non-radiological hazards that will remain on or adjacent to the site when the operator has completed all planned operations involving radioactive substances.

5.2.10 The SWESC should describe the site reference state (see Glossary for definition).

5.2.11 The SWESC should also describe the state of the site at the time when all planned work on site involving radioactive substances has ceased. That state may, or may not, be the same as the site reference state. If it is not the same, the SWESC should demonstrate that the site reference state will be reached from that state through natural processes including radioactive decay, dilution and dispersion, within a claimed period of time. During this claimed period of time (the 'period of restricted use'), there will be controls on the use of the site. The SWESC should identify these controls and substantiate that they are sufficient. It is unlikely that the environment agencies would accept a claim for a period of restricted use lasting longer than 300 years, because of the major social changes that may take place over long periods of time.

5.2.12 The SWESC should identify whether validation monitoring is needed after the time when all planned work on site involving radioactive substances has ceased and, if so, specify the nature and duration of that validation monitoring. Validation monitoring is monitoring to confirm that the state and behaviour of the site is in

accordance with the assumptions of the SWESC. The period of restricted use cannot be less than any period of validation monitoring.

5.2.13 In addition, the SWESC should demonstrate that people and the environment will be adequately protected while work on site involving radioactive substances is still continuing. As well as considering the progress of the work in accordance with the WMP, the SWESC should consider unplanned, but reasonably foreseeable, events and faults. It need not consider extreme faults and accidents.

5.2.14 The claims made in the SWESC should be substantiated by a structured collection of arguments and evidence. The SWESC need not be a stand-alone document or suite of documents, and can make reference to any documentation that provides evidence to support the case. However, there needs at least to be a top level, or 'head', document that provides a focus for the SWESC. We provide further advice on the structure and content of the SWESC in Chapter 6.

5.2.15 The SWESC should support any application from an operator to seek release from radioactive substances regulation.

5.2.16 Figure 4 provides a timeline showing the progressive development of the SWESC and also when in the SWESC the dose constraint under Requirement R5 applies and when the risk guidance level under Requirement R6 applies.

5.2.17 The environment agencies recognise the possibility that one or more near-surface disposal facilities (either purpose-built or adapted from existing structures) may be constructed on a nuclear site, in addition to radioactivity being left in situ on the site. Figure 5 illustrates the relationship between the common principles and requirements that apply for the purpose of the SWESC and the NS-GRA for a range of possible dispositions of anthropogenic radioactivity that may remain upon or adjacent to a decommissioned site, any combination of which may describe the circumstances of a given site. To deal with such cases there is a need for a consistent approach to assessing the impacts of the total inventory of anthropogenic radioactivity remaining on the site. We consider that the principles and requirements set out in this document provide the basis for such an approach.

Requirement R4. Waste management plan

5.2.18 **The operator should provide a waste management plan (WMP) to set out the approach to achieving release of the site from radioactive substances regulation.**

5.2.19 We expect the operator to assess, plan and begin to undertake the work necessary to bring the site into a condition that meets the other requirements in this chapter. This should commence as soon as practicable during the operational phase of a nuclear site.

5.2.20 To achieve this, the operator should develop and maintain a waste management plan (WMP) (see Glossary for definition), as part of its wider decommissioning plans. The WMP is closely linked to the SWESC (see Requirement R3) and the operator should develop them together, and maintain consistency between them.

5.2.21 As a minimum the WMP needs to:

- identify all current and prospective disposals of radioactive waste on site;

- demonstrate that any proposed on-site disposals of radioactive waste are optimised;
- demonstrate that the disposals are consistent with the evidence and arguments presented in the SWESC; and
- demonstrate an integrated approach to the management of all waste, both radioactive and non-radioactive, over the lifetime of the facility.

5.2.22 The waste management plan must cover all forms of radioactive waste, including:

- existing waste;
- waste anticipated to arise; and
- waste in situ;

and all forms of disposal such as:

- disposal by transfer off site;
- disposal by emplacement on site, e.g. into an on-site waste disposal facility or for a purpose, such as void filling; and
- disposal by deliberately leaving waste in situ.

5.2.23 The operator will need to apply for, and be granted, authorisation under the permit before physically emplacing waste into or onto the ground, or to allow waste already in situ to remain there permanently. A WMP and a SWESC, that are comprehensive, credible and mutually consistent, are prerequisites for granting such authorisation.

5.2.24 We provide further guidance on the purpose and content of a WMP in Chapter 7.

Requirement R5. Environmental safety culture and management system

5.2.25 **The operator should continue to nurture a positive environmental safety culture suitable for the activities being undertaken on the site and should have a management system, organisational structure and resources sufficient to provide the following functions: (a) planning and control of work; (b) the application of sound science and good engineering practice; (c) commissioning of appropriate research and development; (d) provision of information; (e) documentation and record-keeping (see also Requirement R14); (f) quality management.**

5.2.26 We shall expect the operator to nurture a positive environmental safety culture, such as appropriate individual and collective attitudes and behaviours, and require its suppliers to do the same. This culture needs to be reflected in and reinforced by the operator's management system.

5.2.27 The operator's management system should ensure that sufficient protection is provided to people and the environment against radiological and associated non-radiological hazards during decommissioning and clean-up and subsequently. In other words, the management system should reflect a proportionate approach.

5.2.28 The operator needs to demonstrate to us that, throughout the changes on site leading towards release from RSR, its organisation will remain fully capable of assuring environmental safety by implementing a management system that includes effective leadership, proper arrangements for policy and decision making, a suitable range of competencies, provision of sufficient resources, a commitment to continuous learning and proper arrangements for succession planning and

knowledge and records management. The management system should be progressively adapted to provide suitable corporate governance of the organisation during the whole process of decommissioning and clean-up.

5.2.29 The written management arrangements supporting the management system should show how, with an appropriate environmental safety culture, environmental safety is directed and controlled. They should also show how the management system is maintained "live" through regular review, progressive updating and implementation of the management arrangements.

5.2.30 Throughout the permit lifetime, the operator should have a management system in place that provides a level of control proportionate to the hazard. The management arrangements for a site undergoing decommissioning and clean-up, and approaching surrender of the permit, can thus change with the stage of the work reached. While we expect the management arrangements to become broadly simpler over time, they should always be fit for the purposes that are current.

5.2.31 For more detail on the factors that the environment agencies will consider in our evaluation of an operator's management system, see Requirement 4 in the NS-GRA (Environment Agency et al 2009) and the Environment Agency's guidance on arrangements at nuclear sites (2010).

5.3 Radiological requirements

Requirement R6. Dose constraints during the period of radioactive substances regulation

5.3.1 **During the period of radioactive substances regulation the effective dose to a representative member of the critical group from the whole site should not exceed a source-related dose constraint and a site-related dose constraint.**

5.3.2 The environment agencies are required (Scottish Executive 2000 and EPR 10) to have regard to the following maximum doses to individuals which may result from a defined source, for use at the planning stage in radiation protection:

- 0.3 mSv per year from any source from which radioactive discharges are made; and
- 0.5 mSv per year from the discharges from any single site.

5.3.3 The dose constraints place upper bounds on optimisation that apply during the period of RSR. They cease to apply when the site is released from RSR.

5.3.4 For comparison with the source-related dose constraint, the assessment of effective dose should take into account both direct radiation from each source on site and radiation from current discharges attributable to that source. Clearly defined individual facilities, whether operating or decommissioning, and including ancillary plant, should be regarded as sources. As a general guide, whatever was regarded as a single source during operation should also be regarded as a single source during decommissioning. For example, all the reactors forming part of a single power station, whether or not all have reached the decommissioning stage, should be regarded as a single source, but A and B nuclear power stations on the same site should be regarded as separate sources. A dedicated disposal facility on a nuclear site should also be regarded as a single source.

5.3.5 For comparison with the site-related dose constraint, the assessment of effective dose should take into account radiation from current discharges from the site as a whole. The site-related dose constraint applies to the aggregate exposure from a number of sources with contiguous boundaries at a single location, i.e. the sources may be on the same site (including tenants) or on adjoining sites (e.g. A and B nuclear power stations). It applies where some of the sources are undergoing decommissioning and clean-up while others remain operational. It also applies irrespective of whether different sources on the site are operated by the same or different organisations.

5.3.6 The operator should carry out decommissioning, clean-up and radioactive waste disposal in accordance with a WMP, which the operator has determined beforehand. The WMP should be consistent with the SWESC. The SWESC should demonstrate conformity with the source constraint and the site constraint both in the present and looking forward throughout the envisaged lifetime of the permit.

5.3.7 The permit will include limits on operational discharges and disposals. During the lifetime of the permit our regulatory approach regarding current radioactive discharges and disposals will be the same as for any other authorised site. We shall expect the operator, in accordance with the permit, to:

- monitor and assess radioactive discharges from the site and levels of radioactivity in the environment;
- have plans for action if monitoring suggests an unexpected release from the site;
- put into action remediation plans if any adverse anomalies are identified as a consequence of monitoring;
- carry out dose assessments based on the levels of radioactive discharge permitted by the authorisation (prospective assessments) and assessments based on the levels of radioactivity measured in the environment (retrospective assessments);
- report this information to us.

Requirement R7. Risk guidance level after release from radioactive substances regulation

5.3.8 **After release from radioactive substances regulation, the assessed risk from the remaining radiological hazards to a person representative of those at greatest risk should be consistent with a risk guidance level of 10^{-6} per year (that is, a risk of death of 1 in a million per year due to exposure to ionising radiation).**

5.3.9 We use the term “risk guidance level” (see Glossary) to describe the assessment standard for natural evolution of the system after the site has been released from RSR, because it indicates the standard of environmental safety we are seeking, but does not suggest that there is an absolute requirement for the stated level to be met. The value of 10^{-6} per year is consistent with advice given in the Health and Safety Executive (HSE) publication “Reducing Risks, Protecting People” (HSE 2001). The HSE publication identifies this value as “a very low level of risk” which should be used as a guideline for the boundary above which people are prepared to tolerate risks in order to secure the benefits from the activities giving rise to the risks and below which risks are broadly accepted by society because they are generally regarded as insignificant.

5.3.10 The risk guidance level applies to assessed risks from radioactivity dispersed in the accessible environment due to the migration or uncovering of radioactivity by natural processes. The period for assessing these risks should be chosen to ensure that peak risks are considered. This period will vary depending on the hazard presented by the radioactivity and the processes acting on the system.

5.3.11 The assessed radiological risk associated with a potential exposure situation corresponds to the product of the estimated effective dose that could be received, the estimated probability (as a quantified uncertainty – see below) that this dose will be received and the estimated probability that detriment would occur as a consequence to the person exposed. For comparison with the risk guidance level, assessed risks need to be summed over all situations that could give rise to exposure of the same person to radiation.

5.3.12 For situations in which only stochastic effects of radiation exposure need to be considered (i.e. when the estimated annual effective dose is less than 100 mSv and the estimated equivalent dose to each tissue is below the relevant threshold for deterministic effects), a risk coefficient of 0.06 per Sv should be used. This corresponds to recommendations set out in advice given by Public Health England (PHE, formerly the Health Protection Agency (HPA)) in its publication on the disposal of solid radioactive waste (HPA 2009).

5.3.13 For further discussion see paragraphs 3.6.15-16 of the Near-Surface GRA.

Risk assessment

5.3.14 Risk assessment aimed at showing consistency with the risk guidance level helps to inform the operator about how models and research should be directed and developed, by highlighting which model components dominate risk and to which parameters risk is sensitive. It also has the important role of informing our regulatory decision making.

5.3.15 We have chosen a cautiously low value for our risk guidance level. It is not necessary when expressing the aggregate risk for comparison with the risk guidance level to include an additional conservative bias. The expectation (mean) value of risk is an example of a measure that does not include such a bias, but other measures could also be devised that might be more suitable in particular circumstances. We shall expect the operator to demonstrate that the measure chosen is reasonable. Information about the sensitivity of the chosen measure to important parameter values should also be presented.

5.3.16 The complexity or sophistication of a risk assessment should be proportionate to the radiological hazard. For some nuclear sites, the operator may be able to avoid using complex models in the risk assessment by making simple conservative assumptions.

5.3.17 In setting up a risk assessment, in general the operator should aim for data and assumptions that represent realistic or best estimates of the system behaviour. However, where the data do not support this approach or where the assessment can usefully be simplified, the operator may choose some data and assumptions to be conservative as long as the requirements are still shown to be met.

5.3.18 In cases where the hazard remaining on or adjacent to a site warrants a detailed assessment of risks, we shall expect a probability distribution of dose to be one of the outputs from each risk assessment that the operator undertakes. The probability

distribution will cover the range of possible doses that a person representative of each potentially exposed group may receive and will provide the probability that this person receives any given dose. The probability distribution will vary with time into the future. Various different probability distributions of dose could give the same aggregate risk, and hence could be equal in terms of acceptability against the risk guidance level.

Uncertainties

5.3.19 Uncertainties arise from diverse sources and have a number of different characteristics. They are caused, for example, by natural variability, practical limitations on sampling relevant processes and data, alternative interpretations of data, and natural events and future human behaviour that may affect radionuclide release, transport and exposure pathways. How significant they are depends on the effect they could have on the arguments used in the SWESC.

5.3.20 After the permit has been surrendered, the evolution of the site becomes increasingly uncertain with time. An important distinction can be made between two types of uncertainty: those that can reliably be quantified and those that cannot. Whatever the origin and nature of an uncertainty, the same basic issue arises as to whether the uncertainty can reliably be quantified. If an uncertainty is quantified without a reliable basis, it will devalue a numerical risk assessment into which it is introduced and it thus needs to be dealt with by other means.

5.3.21 An uncertainty cannot reliably be quantified if, for example, it is not possible to acquire relevant data, or if acquiring enough data to evaluate it statistically could only be done at disproportionate cost. Important examples of uncertainties that cannot reliably be quantified (i.e. that are effectively unquantifiable) include those associated with future human actions and with certain rare events for which the data available historically do not provide an adequate basis for statistical evaluation. An example of such a rare event might be a severe earthquake at a particular location in a region of generally low seismicity (see Figure 6).

5.3.22 We expect that quantifiable uncertainties will be considered within a numerical risk assessment developed as part of a site wide environmental safety case (see Chapter 6). Unquantifiable uncertainties will also need to be taken into account in developing the case, but should be kept apart from the quantifiable uncertainties and given separate consideration. Taking into account unquantifiable uncertainties will inevitably involve judgement. Identifying significant unquantifiable uncertainties is a necessary first step, since judgements about them cannot be made until this is done. The judgements should then be based on ‘balance of likelihood’ rather than on ‘beyond reasonable doubt’, so that outcomes are not unduly influenced by remote possibilities.

5.3.23 One way of exploring unquantifiable uncertainties about future events is through the use of separate risk assessments for each set of possible events. Each set of events, or scenario, is assigned a nominal probability of one and a risk assessment that accounts for the remaining, quantifiable, uncertainties is carried out. There may be several risk assessments because there may be several scenarios. The resulting calculated risks are compared to the risk guidance level, bearing in mind how likely it might be that the assumptions made in setting up the scenarios would correspond to circumstances arising in practice.

5.3.24 Some scenarios will involve future events so uncertain that it may not be appropriate to undertake numerical risk assessments for comparison with the risk guidance

level, as this could distort the overall picture of risks. These scenarios might include a range of "what-if" scenarios. Such scenarios may affect whether or not the environmental safety case overall is judged acceptable and the environment agencies will need to consider them one by one. Advice on human actions that affect the SWESC is given under Requirement R8 below, while advice on natural disruptive processes is given under Requirement R9.

Exposed groups

5.3.25 Risk assessments will need to consider different groups of people that could be at risk of exposure (potentially exposed groups) in order to identify a person representative of those people at greatest risk at a given time. There is a range of possible doses that each group might receive and, for each dose, an assessed probability of their receiving that dose.

5.3.26 The operator will need to substantiate the choice of potentially exposed groups as being reasonable and suited to the particular circumstances. The location and characteristics of the groups considered should be based on the assessed releases of radioactivity and on assumptions about changing environmental conditions. The habits and behaviour assumed for people in potentially exposed groups should be based on present and past habits and behaviour that have been observed and that are judged relevant. Metabolic characteristics similar to those of present-day populations should be assumed. The other parameters used to characterise a representative member of a potentially exposed group should be generic enough to give confidence that the assessment of risk will apply to a range of possible future populations.

Combining risks from different nuclear sites

5.3.27 If two or more separate nuclear sites present significant risks to the same potentially exposed groups, consideration will need to be given to the combined risks to those exposure groups. An unacceptably large total for the assessed risks from different nuclear sites affecting the same exposure group at the same time could indicate an unacceptably large assessed risk from one or more of the sites taken individually. This would require attention from the operator(s) and ourselves. We would also not accept an approach in which the assessed risks from multiple different hazards associated with the same nuclear site were put forward individually in order to show that each hazard, taken alone, presented a risk consistent with the risk guidance level.

Regulators' considerations

5.3.28 When considering the merits of a SWESC for the purpose of regulatory decision-making, we shall use all the information put forward in the SWESC to inform our decision. We shall make a judgement about whether the degree of consistency that the operator is able to demonstrate with the risk guidance level is good enough. This judgement will take account of the uncertainties that have been included in the risk assessment as well as information from the operator on the uncertainties that have not been included in the risk assessment.

5.3.29 We are likely to be satisfied with a risk assessment if we judge that: (a) it is unlikely to be presenting an optimistic picture; (b) the consistency with the risk guidance level is good enough; and (c) the probability distributions of dose presented for different future times show that larger doses are, in broad terms, matched by correspondingly smaller probabilities.

5.3.30 If we judge that there is a significant discrepancy between the results of a risk assessment and the risk guidance level, or if the probability distribution of dose at some future time causes us concern, we shall need additional assurance from other information presented in the SWESC to satisfy us that an appropriate level of environmental safety is assured.

Requirement R8. Human intrusion dose guidance level after the site reference state has been reached

5.3.31 **The operator should assess the potential consequences of human intrusion into any part of the site after the site reference state has been reached (that is, once the site is available for unrestricted use) on the basis that it is likely to occur. The operator should, however, consider and implement any practical measures that might reduce the chance of its happening. The assessed effective dose to any person during and after the assumed intrusion should not exceed a dose guidance level in the range of around 3 mSv/year to around 20 mSv/year. Values towards the lower end of this range are applicable to assessed exposures continuing over a period of years (prolonged exposures), while values towards the upper end of the range are applicable to assessed exposures that are only short term (transitory exposures).**

5.3.32 The standard against which human intrusion should be assessed is specified in terms of dose, not risk. Because the likelihood of human intrusion cannot reliably be assessed in terms of a numerical value of probability, dose is in effect being used as a surrogate for risk when considering intrusion. We use the term *dose guidance level* (see Glossary) in this document to describe the assessment standard, because it indicates the standard of environmental safety we are looking for, but does not suggest that there is an absolute requirement for this level to be met. The range of around 3 mSv/year to around 20 mSv/year that we specify for our dose guidance level is the same as the advice issued by the Public Health England (PHE, formerly the Health Protection Agency (HPA)) in its publication on the disposal of solid radioactive waste (HPA 2009).

5.3.33 The operator needs to assess potential exposures of possible intruders to the radiological dose that might arise from a range of possible exposure scenarios. These scenarios should consider exposures that might arise from the radioactive substances remaining on or adjacent to a site including any gaseous emissions from these substances such as radon; this should not include exposures to naturally occurring radon. Due to the large uncertainties associated with exposures to radon the operator should present these both aggregated with other exposures and individually.

5.3.34 Dose assessments carried out for the purpose of comparison with the dose guidance level should take into account discrete, individually-contaminated items that people might encounter as a result of human intrusion. Such items might range in size from particles to large objects that would be visually identifiable and might be of a recognisable type (such as a hand tool). For smaller items, the operator should consider the possibility that people, including children, might ingest them or inhale them.

5.3.35 The operator should also carry out assessments to show that the consequential effects of human intrusion on non-human species are acceptable.

5.3.36 The operator will need to show that dose thresholds for severe deterministic injury to individual body tissues are unlikely to be exceeded as a result of human intrusion.

Severe deterministic injury means injury that is directly attributable to the radiation exposure, that is irreversible in nature and that severely impairs health and/or the quality of life of that individual, for example, lung morbidity and early death.

Applicability of dose guidance level

5.3.37 Human intrusion may be regarded as falling into three classes: (i) intrusion with full knowledge of the existence, location, nature and contents of the former nuclear site; (ii) intrusion without prior knowledge of the site; and (iii) intrusion with knowledge of the existence of a former site but without understanding its nature. We do not expect the operator to consider the first of these classes because we take the view that a society that preserves full knowledge of the nuclear site will be capable itself of exercising proper control over any intrusions into the site. We expect the operator to consider the second and third of these classes. Examples of the second class would be exploratory drilling for mineral resources because the local geology appears promising, and excavation during future development of the site. An example of the third class would be an archaeological investigation carried out without knowing about or understanding radioactivity, but recognising that there has been human activity at the site in the past.

5.3.38 We regard the following as events for which our dose guidance level of around 3 mSv/year to around 20 mSv/year is the standard that applies after the site reference state has been reached:

- human intrusion directly into radioactive substances remaining on or adjacent to a site ;
- other human actions that damage barriers or degrade their functions, such as removing material from the cap of any disposal facility on site. Barriers considered to be affected by these human actions may be engineered, natural, or a combination of both.

5.3.39 Beyond the region where these kinds of event might happen, the risk guidance level of Requirement R7 is the standard that applies to future human actions. The risk guidance level applies where radionuclides have spread beyond barriers and are subject to mechanisms of dilution and dispersion, including where there has been disturbance by human action. An example of a future human action to which the risk guidance level applies is the sinking of a well into an aquifer contaminated by radionuclides from a nuclear site.

5.3.40 Where barriers that provide environmental safety functions are natural, rather than engineered, they may have a considerable spatial extent. In this case, we would discuss with the site operator how far from any radiological hazard remaining on or adjacent to a site it is reasonable to apply the dose guidance level rather than the risk guidance level, recognising that the circumstances in every case may be different. The value of invoking barriers that are natural in origin and their associated environmental safety functions needs to be weighed against the undesirability of invoking the dose guidance level over a wide area.

Measures to reduce the likelihood of human intrusion

5.3.41 The operator should consider, and implement, any practical measures that might reduce the likelihood of human intrusion. We encourage such measures where they are likely to be beneficial. We may not accept that an absolute claim can be made in the SWESC for their effectiveness, but it may still be useful to invoke them in contributory, qualitative arguments included in the SWESC. We recognise that it is

not easy to judge the benefits of these measures and that some measures, such as providing a marker at the surface, might in the longer term have the opposite of the intended effect. We also recognise that there are practical limits to what can be done. In particular, it is important that any measures intended to reduce the likelihood of human intrusion do not compromise the environmental safety performance claimed in the SWESC if human intrusion does not occur. We shall expect the operator to consider measures to reduce the likelihood of human intrusion as part of option studies under Requirement R9, Optimisation. Implementation of any measures intended to reduce the likelihood of human intrusion is subject to our agreement to those measures.

Assessing the consequences of human intrusion on people and the environment

5.3.42 The timing, type and extent of human intrusion into a nuclear site are so uncertain that they need to be explored through one or more 'what-if' scenarios, separate from the scenarios representing evolution of the site undisturbed by human intrusion that are considered under Requirement R7, Risk Guidance Level.

5.3.43 Human intrusion scenarios should be based on human actions that use technology and practices similar to those that currently exist, or that have historically existed, in similar geological and geographical settings anywhere in the world. The assumed habits and behaviour of people should be based on present and past human habits and behaviour that have been observed and are judged relevant. Scenarios should include all human actions associated with any material removed from the nuclear site, including considering what is then done with this material. The number of people involved in actions associated with intrusion should be assessed, and may be assumed to be similar to the typical number involved in similar actions now or historically. Similarly, the number of people who might be exposed as a result of occupying the site or neighbourhood after the intrusion should also be assessed. These numbers will be important in assessing radiological effects for optimisation purposes (see 5.3.46). The operator will need to substantiate each scenario considered as being reasonable and suited to the particular circumstances.

5.3.44 The operator should present assessments of radiation doses to individuals representative both of those undertaking the intrusion and of those who might occupy the site or the neighbourhood afterwards. The assessments presented should also explore the consequences of intrusion in a wider geographical sense and on the long-term behaviour of the site after disturbance in this manner. The assessments should take into account all radionuclides that may be present and all decay products making a significant contribution to dose.

5.3.45 The operator should present assessments of the radiation doses received by non-human organisms as a result of human intrusion into the facility and demonstrate that these are not at a level liable to cause significant harm to populations of such organisms (see also Requirement R10 below).

5.3.46 We shall expect the operator to use the results from the human intrusion scenarios above as part of option studies under Requirement R10, Optimisation. The aim will be to reduce the radiological effects resulting from human intrusion, subject to balancing all the other considerations relevant to optimisation.

5.3.47 Figure 7 illustrates the approach described above to human intrusion after the authorisation has been revoked.

Practical measures and claims in the SWESC

5.3.48 Because of the uncertainties surrounding human intrusion and other unpredictable and disruptive events, a difference may arise between what would seem on balance to be desirable practical measures to reduce the likelihood or consequences of disruption and what can reasonably be claimed in the SWESC. In such cases, we may expect or require the operator to take practical measures that go beyond what we accept as a substantiated claim in the SWESC.

5.3.49 For substances containing radiologically significant quantities of long-lived radionuclides, it is possible that human intrusion could result in doses around the dose guidance level. In such cases, we would expect the operator's plans for decommissioning and clean-up to give full consideration to measures to reduce the likelihood or consequences of intrusion. Measures that may be warranted by the consequences include immobilisation or isolation in situ, or extraction to allow for disposal on or off the site.

5.3.50 For many substances presenting some degree of radiological hazard that might be left on a former nuclear site, human intrusion after release of a site from RSR and any period of subsequent control is likely to result in doses well below the dose guidance levels. In such cases, we would look for any possible proportionate measures for reducing the likelihood of intrusion.

Other considerations

5.3.51 Where a non-radiological hazard is associated with the radiological hazard (as with radioactively contaminated asbestos, for example), the operator should include an assessment in the SWESC to demonstrate adequate protection against the non-radiological hazard presented by the radioactive substances exposed by human intrusion (see also Requirement R11).

5.3.52 The operator should also carry out assessments to show that the consequential effects of human intrusion on non-human species are acceptable (see also Requirement R10).

Requirement R9. Natural disruptive processes after release from radioactive substances regulation

5.3.53 **The operator should show in the SWESC that people and the environment will be adequately protected in the case of natural disruptive processes after the site is released from radioactive substances regulation.**

5.3.54 A nuclear site may be subject to natural disruptive processes after release from radioactive substances regulation. In particular, many nuclear sites are in coastal or estuarine locations, or are adjacent to watercourses. If engineered provisions such as sea or flood defences and site drainage systems are not adequately maintained a site may eventually be subject to natural disruptive processes such as coastal erosion or flooding. The onset and severity of these processes may be exacerbated by factors such as climate change and sea level rise. It is possible that buried radioactive substances might become exposed to the accessible environment by such processes while these substances still present a significant hazard.

5.3.55 In assessing the consequences of natural disruptive processes, the operator should not rely on the repair and maintenance of engineered provisions such as sea or flood defences and drainage systems, except where the operator can identify an

organisation that is willing and technically competent to take responsibility for carrying out such repair and maintenance, and that also has access to suitable financial provisions.

5.3.56 The radiological risks that may arise from coastal erosion are likely to be mainly from the progressive exposure of radioactive substances in the face of the eroding foreshore. The radiological risks that may arise from flooding are likely to be mainly from leaching of radioactive substances from the flooded land, although repeated or persistent flooding may also expose radioactive substances by surface erosion.

5.3.57 In some cases, natural disruptive processes such as coastal erosion and flooding may give rise only to exposure or leaching of radioactive substances that are broadly homogeneous, without any local concentrations of radioactivity. In such cases, the operator should include suitable scenarios in the SWESC to assess the risks and should compare the results of the assessments with the risk guidance level under Requirement R7.

5.3.58 In other cases, local concentrations of radioactivity or discrete, individually-contaminated items may become accessible for people to receive a dose from them. Such concentrations or items might range in size from particles to large objects and might include visually identifiable objects of a recognisable type, such as a hand tool.

5.3.59 Items the size of a particle, indicatively up to around 1 mm in diameter, require special consideration. People will experience only random encounters with particles unless they have a means of identifying them individually. Metallic particles, for example, could be identified using metal detectors and hence could be separated and collected. It may be reasonable to assume that suitable precautions will be taken in handling a particle if the persons concerned recognize it as radioactive, but they will not necessarily do so. For particles encountered randomly, the operator should include suitable scenarios in the SWESC and assess risks against the risk guidance level under Requirement R7.

5.3.60 For local concentrations of radioactivity or discrete, individually-contaminated items, except for particles randomly encountered, the operator should carry out illustrative dose assessments, comparing the results of the assessments with the dose guidance level for human intrusion under Requirement R8. For smaller items or particles that have been identified by some means, the operator should consider the possibility that people including children might ingest them or, for particles, inhale them.

5.3.61 The likelihood of people encountering local concentrations of radioactivity or discrete, individually-contaminated items exposed by natural disruptive processes cannot reliably be assessed in terms of a numerical value of probability. In this respect, the case is similar to human intrusion (Requirement R8). In both cases, dose is used as a surrogate for risk.

5.3.62 When applying the dose guidance level in the range of around 3 mSv/year to around 20 mSv/year set out in Requirement R8 we consider that values towards the lower end of this range are likely to be more generally applicable. This is because where natural disruptive processes uncover local concentrations of radioactivity or discrete, individually-contaminated items, most exposure scenarios are likely to continue for a period of years (prolonged exposures). The upper value of the range is included to allow for possible scenarios with only short term (transitory) exposures.

5.3.63 Where a non-radiological hazard is associated with the radiological hazard (as with radioactively contaminated asbestos, for example), the operator should include an assessment in the SWESC to demonstrate adequate protection against the non-radiological hazard presented by the exposed radioactive substance (see also Requirement R12).

5.3.64 We shall expect the operator to show that intrusion by non-human species, including plant species (for example tree roots), is not a significant issue.

5.3.65 The operator should also include assessments in the SWESC to show that non-human species are adequately protected (see also Requirement R11).

Requirement R10. Optimisation

5.3.66 **The operator should bring the site to a condition at which it can be released from radioactive substances regulation, through an optimisation process. This process should ensure that the radiological risks to individual members of the public and the population as a whole are kept as low as reasonably achievable (ALARA) throughout the period of radioactive substances regulation and afterwards, as far as can be judged at the time when relevant actions are taken. Such optimisation shall take into account economic and societal factors and the need to manage radiological risks to other living organisms and any associated non-radiological hazards.**

5.3.67 Optimisation is about finding the best way to bring the site to a condition such that the radiological risks to individual members of the public and the population as a whole are as low as reasonably achievable (ALARA) throughout the period of RSR and afterwards.

5.3.68 During the period of RSR this may be achieved by reducing direct and/or indirect radioactive discharges. Indirect discharges are discharges from radioactive waste already disposed of and/or associated with radioactively contaminated land or groundwater. The dose constraints (Requirement R6) place upper bounds on optimisation during the period of RSR.

5.3.69 After the period of RSR, the objective is to reduce radiological risk. This may be achieved by reducing the probability that an exposure will be received as well as by reducing the exposure. Requirement R7 and Requirement R8 set out risk and dose guidance levels after the end of the period of RSR. However, although reducing radiological risk is important, it should not be given a weight out of proportion to other considerations. In other words, the best way forward is not necessarily the one that offers the lowest radiological risks.

5.3.70 Optimisation will need to balance many considerations including, but not limited to:

- Ensuring worker safety;
- Minimising waste generation and providing for effective and safe management of wastes that are created;
- Minimising environmental effects including the re-use and recycling of materials;
- Using resources effectively, efficiently and economically;
- Using best practice;
- Public acceptance;

- Proportionate site decommissioning and clean-up; and
- Establishing an acceptable SWESC, taking into account radioactive waste and/or contamination still remaining on or adjacent to a site.

5.3.71 The timing of decommissioning, including the timing of radioactive waste disposals, is also a consideration which needs to be taken into account in the optimisation process.

5.3.72 To identify the best way forward, the operator should carry out options studies where there are choices to be made among significantly different alternatives. The operator should present the results to us and make them publicly available. The studies will inform the operator's decisions. We will not agree to an approach that ignores optimisation by not considering such choices and is based only on assessing supposedly acceptable levels of residual activity consistent with Requirements R7 and R8.

5.3.73 In these studies, the operator should consider in relation to the management of the generation and disposal of radioactive waste:

- the extent and manner of decommissioning and clean-up;
- the resulting generation of radioactive and other wastes for disposal;
- whether wastes are to be disposed of on site or consigned for disposal elsewhere.

5.3.74 In addition to the general considerations identified above, the operator should have regard to issues such as the following in assessing options:

- the extent to which is it is proportionate to remediate radioactively contaminated land and groundwater on or adjacent to a site;
- the availability of suitable disposal facilities for radioactive waste retrieved or created;
- the effort and cost of retrieving or creating the waste and putting it into a form suitable for transport and disposal;
- the effort and cost of transport and disposal themselves; and
- radiation exposure and other sources of risk associated with all the operations involved.

5.3.75 To succeed, optimisation requires good communication, both within the operator's own organisation and with supplier organisations, as well as with the regulators and members of the public, including especially the local community.

5.3.76 The decommissioning and clean-up of a nuclear site through to release from RSR may be seen as the successive implementation of a series of decisions made by the operator. These decisions should flow from an overall plan, which includes the WMP, for managing decommissioning, clean-up and site restoration. Such a plan may need to be varied in the light of emerging information from investigations carried out as work proceeds. This may be especially true for older facilities, where the as-built design and the state of the plant may be imperfectly known.

5.3.77 In the light of this, each decision that changes or updates the plan may be relevant to optimising the decommissioning, clean-up and restoration process and so optimisation needs to be considered at each such stage. Once a decision has been implemented, it forms part of the knowledge framework within which further

decisions, and the optimisation considerations that go with them, must be made. Even when a decision has apparently been made, it continues to represent an uncertainty before it has been implemented, because the decision still might not be implemented or might be implemented in a way different from that envisaged. Operator decision-making in relation to radioactive substances ends with release from RSR.

5.3.78 The optimisation of a nuclear site undergoing decommissioning, clean-up and restoration is undertaken in the presence of uncertainties that would not exist, or would not exist to the same extent, for a nuclear site in an operational mode. These uncertainties potentially include decisions not yet implemented and how the site might evolve after the site reference state has been reached.

5.3.79 The main optimisation task in the presence of uncertainties is to make sure that an acceptable situation will result, not only in likely future circumstances, but also in circumstances that are possible but unlikely. Acceptability can be measured in terms of radiation dose or risk, but it will often be unnecessary to go as far as calculating these quantities to recognise a situation as unacceptable. We shall judge acceptability in a proportionate way taking account of the circumstances concerned.

5.3.80 Once this main optimisation task has been fulfilled, optimisation follows the more usual path of finding the best way forward for each set of circumstances. At this stage, the operator should focus mainly on the likely circumstances. Unlikely circumstances should not have undue influence on the decommissioning plan.

5.3.81 We prefer a simple approach to optimisation to a more complex one, where either would provide an adequate outcome. If the operator uses a numerical approach to compare options, it should recognise that the size of the population at risk is a relevant issue as well as the magnitude of individual risks. This may involve carefully considering the distribution of risks. A blunt tool such as overall collective effective dose is unlikely to be useful (for further discussion, see paras 5.3.83 and 5.3.84).

5.3.82 At each decision-making stage (i.e. when the decommissioning plan is significantly changed), we shall expect the operator to provide a written record that it has properly considered optimisation. We shall also expect, as part of the SWESC, a historical record of the decisions the operator has taken and implemented, and the optimisation considerations that contributed to those decisions when they were taken.

Collective dose

5.3.83 On the use of collective dose for optimisation, ICRP states (ICRP 2006): "When the exposures occur over large populations, large geographical areas, and long periods of time, the total collective dose (i.e. the summation of all individual exposures in time and space) is not a useful tool for decision aiding because it may aggregate information excessively and could be misleading for selecting protective actions". ICRP also states that collective dose is not intended as a tool for epidemiologic risk assessment, and it is inappropriate to use it in risk projections. In particular the calculation of the number of cancer deaths based on collective doses from trivial individual doses should be avoided. PHE (formerly HPA) states (HPA 2009) that it concurs with this view for assessments of solid waste disposal.

5.3.84 PHE states that, in situations where collective doses are useful, the ICRP document advises on a move away from collective doses to ‘group’ doses, thus taking earlier guidance on disaggregation a step further. Essentially ICRP recommends that, in

broad terms, the concept of collective dose is retained but within the context of a 'dose matrix'. However, as a report by PHE and the Centre d'études sur l'évaluation de la protection dans le domaine nucléaire (CEPN, France) (Smith et al 2007) found, there is little to be gained from the 'dose matrix' approach for times far into the future. Collective doses and 'group' doses should only be calculated for times where they can be a useful discriminator between different management options. This is likely to be of the order of several hundred years after the site reference state has been reached but the exact length of time will depend on the nature of the radiological hazards remaining on or adjacent to a site. However, it is not advisable to consider the very long term collective dose to members of the public in view of the large uncertainties. These uncertainties effectively make any comparison meaningless.

Requirement R11. Environmental radioactivity

5.3.85 **The operator should carry out an assessment to investigate the radiological effects of the site on the accessible environment with a view to showing that all aspects of the accessible environment are adequately protected, both during the period of, and after release from radioactive substances regulation. The assessment should include consideration of any envisaged period of restricted use after the permit has been surrendered.**

5.3.86 Discharges and migration of radionuclides from a decommissioned site might have a detrimental effect on the accessible environment, through effects on non-human species. This requirement aims to ensure that all aspects of the accessible environment are protected.

5.3.87 In addition, there is a range of statutory provisions relating to habitat, biodiversity and conservation matters that the environment agencies need to take account of under RSR. These are described in sections 9.5 and 9.6 of our guidance on "Near-surface Disposal facilities on Land for Solid Radioactive waste". We will only authorise disposals and release sites from regulation when we are satisfied that these provisions are met.

5.3.88 At the time of publication there are no statutory criteria for determining radiological protection of the environment. A number of research studies and regulatory guidance documents have proposed criteria and assessment approaches (e.g. Andersson et al. 2008; Copplestone et al. 2001, and "Environmental Risk from Ionising Contaminants: Assessment and Management" (ERICA)). We currently use ERICA for our own assessments of radiological impacts of discharges upon biota.

5.3.89 We expect the operator to carry out an assessment and to draw conclusions about the effects of the site on the accessible environment using the best available information at the time of the assessment. The operator should provide this assessment as an integral part of the SWESC and should update it as new information becomes available and when other parts of the case are updated. We expect the extent and complexity of the assessment to be proportionate to the radiological hazard presented by the site.

5.3.90 The assessment of effects on the accessible environment should include (a) an assessment of the effects after human intrusion and (b) an assessment of the effects after natural disruptive processes, in both cases considering the same situations as when assessing the effects on people, as well as any other plausible situations that might have a greater effect on relevant parts of the accessible environment.

5.4 Technical requirements

Requirement R12. Protection against non-radiological hazards

5.4.1 **The operator should bring the site to a condition at which it can be released from radioactive substances regulation, through a process that will protect people and the environment against any non-radiological hazards associated with the radiological hazards both during the period of, and after release from, radioactive substances regulation. The level of protection should be consistent with that provided by the national standard applicable at the time when relevant actions are taken.**

5.4.2 Some radioactive substances remaining on a site may be potentially harmful wholly or partly because of their non-radioactive properties. There are nationally acceptable standards for managing hazardous substances. However, these standards may not be suitable to apply directly to radioactive substances that present both radiological and non-radiological hazards. Accordingly, these standards need not necessarily be applied, but a level of protection should be provided against the non-radiological hazards that is no less stringent than would be provided if the standards were applied.

5.4.3 In some instances, the non-radiological hazards may be greater or more persistent than the radiological hazards. Non-radiological hazards may be to people or to the environment or to both. They may constitute the initial properties of the radioactive substances, or may result from subsequent physical or chemical changes or from chemical or biochemical action. Non-radiological hazards may be presented by a wide range of substances and in diverse ways. Examples of hazardous substances include asbestos, poisonous inorganic chemicals such as heavy metals and their compounds, poisonous organic chemicals such as cyanides, and gases such as methane (generated by biochemical action), that are flammable and/or contribute to climate change.

5.4.4 As stated in paragraph 4.4.2 under Principle 2, optimisation (keeping risks as low as reasonably achievable) only applies to radiological risks. However, adequate protection against non-radiological hazards needs to be maintained, and may be a material factor, when optimising for radiological risks.

5.4.5 The SWESC will need to demonstrate that adequate protection is achieved against non-radiological hazards associated with the radiological hazards, using methods and approaches suited to the nature and proportionate to the magnitude of the non-radiological hazards and suited to the characteristics of the site.

Requirement R13. Site characterisation and monitoring

5.4.6 **The operator should carry out a programme of site characterisation and monitoring to provide information needed to support the SWESC and WMP. This includes monitoring to help identify the future site reference state and to help assess the time within which it will be reached. It also includes appropriate validation monitoring to provide technical confirmation that progress towards the site reference state is as expected.**

5.4.7 Site characterisation and monitoring need to be suited to the information requirements of the SWESC and should be presented as part of a well-structured programme that provides the requisite information. The operator should establish a proportionate approach to site characterisation and monitoring that uses appropriate

studies to guide further investigations, taking into account the nature of operations and former operations on site.

5.4.8 Site characterisation and monitoring need to establish, in sufficient detail:

- The geological properties of the site, including the lithology, the stratigraphy, the geochemistry and the local and regional hydrogeology;
- The potential for, and effects of, dynamic geological processes that may be significant to the SWESC;
- The resource potential of the area under and near the site so as to assess the extent to which the site and its surroundings might in future be disturbed through exploitation of the resources;
- The nature, magnitude and distribution of the radiological hazards remaining on or adjacent to a site;
- The nature, magnitude and distribution of any non-radiological hazards associated with, or potentially interacting with, the radiological hazards;
- Past and present rates of movement and diffusion of these hazards, if for example transported by groundwater, so that extrapolations can be made into the future; and
- Uncertainties in each of the above.

5.4.9 The site characterisation programme will also need to gather sufficient information to provide estimates of background radioactivity present at the site. This will include radioactivity of natural origin, together with that of human origin such as from weapons testing and from any local or remote nuclear accidents.

5.4.10 The operator will need to show that the biosphere is characterised, understood and capable of analysis to the extent necessary to support the SWESC. This may involve consideration of, for example, topography, soils, surface water systems, flora and fauna distributions and human settlement patterns and activities. Characterisation and monitoring of the biosphere should be sufficiently comprehensive to support dose assessments during the period of RSR and should be proportionate to the assumptions made in the SWESC for assessing risks after the permit has been surrendered.

5.4.11 Knowledge of the site characteristics relevant to the SWESC is expected to increase progressively with time. We shall be proportionate in our assessment of the adequacy of the site characterisation and monitoring information presented in the context of an evolving SWESC.

Monitoring programme

5.4.12 The operator should establish a reasoned and proportionate approach to monitoring the site and any disposal facilities it may contain. The monitoring programme will provide data during the period of RSR to ensure that the behaviour of radioactive substances on or adjacent to a site is consistent with the SWESC assessments.

5.4.13 To provide a baseline for monitoring at later stages, the operator may need to begin monitoring soon after the monitoring required to support the SWESC becomes apparent. The same measurements may also inform parts of the site characterisation. Monitoring should include measurements of background

radioactivity in appropriate media, together with geological, physical and chemical parameters relevant to the SWESC.

5.4.14 During the period of RSR, the operator will need to carry out radiological monitoring and assessment to provide evidence of compliance with the limits and conditions of the RSR permit and assurance of radiological protection of members of the public. The operator will also need to demonstrate that the changes in, and evolution of, the parameters monitored are consistent with the SWESC.

5.4.15 The monitoring programme will need to set out clearly the levels of specific contaminants that will trigger action. It should include an action plan to deal with unexpected levels of contamination and an approach to confirming any apparently positive results to avoid inappropriate action being taken in the event of a false positive observation.

5.4.16 In accordance with Principle 4, that unreasonable reliance shall not be placed on human action to protect people and the environment, assurance of environmental safety must not depend on monitoring or surveillance after the permit is surrendered.

Requirement R14. Preservation of knowledge and records

5.4.17 **The operator should provide knowledge and records of the state of the site at the end of the period of radioactive substances regulation, together with records of any continuing restrictions on use and the related controls. The operator should also provide knowledge and records of the site reference state and the assessed time within which that state will be reached, if this time is still in the future. The operator should provide these records in a form suitable for long-term preservation and access, and should propose arrangements for the long-term safe-keeping and management of this material.**

5.4.18 After a permit has been surrendered, neither the former operator nor the relevant environment agency can reasonably be expected to assume continuing responsibility for any matters relating to the permit. However, the operator can pass on the knowledge and records of the site for safe-keeping and management to an organisation or organisations either having, or seeming to have, relevant responsibility or being prepared to accept this responsibility, e.g. the Nuclear Decommissioning Authority or a local planning authority. Whatever subsequently happens to this material is beyond the control of either the former operator or the relevant environment agency (either or both of which may cease to exist, especially in the longer term). Nevertheless, we expect the operator to take all reasonable steps to ensure that such knowledge and records will be preserved.

5.4.19 Before the relevant environment agency will accept release from RSR, it will expect the operator to demonstrate that arrangements have been put in place for the transfer, long-term safe-keeping and management of the knowledge and records of the site (including the site reference state) by a suitable organisation. It will also expect the operator to show that these arrangements can be and are being implemented.

5.4.20 Relevant material will include records of all radiological hazards remaining on or adjacent to the site. It will include, for example, detailed records of any radioactive waste disposals on site. These records will encompass, but will not necessarily be limited to:

- The radiological hazards presented by the waste, including radionuclide inventory, the chemical and physical form of the waste, records of discrete items that have (or may have) elevated levels of activity, and the specific manner of disposal of the waste;
- The non-radiological hazards presented by the waste, supported by appropriate details similar to those for the radiological hazards;
- Any physical measures provided to prevent, or reduce the chances or consequences of, future human intrusion; and
- Any uncertainties that may be of significance in interpreting and using the data recorded.

5.4.21 The operator should provide the knowledge and records in a form that can be interpreted by technical specialists who do not have site-specific knowledge. The operator should also provide material that can be interpreted by lay persons so that they can understand whether and when to involve technical specialists.

5.4.22 In the preparation of records the operator should take account of relevant standards, guidance and codes of practice that are applicable when the permit is surrendered, to maximise the probability that these records and the means of interpreting them will continue to be preserved into the long-term future.

6. Site wide environmental safety case (SWESC) (Requirement R3)

6.1 Introduction

6.1.1 An operator should produce and maintain a site wide environmental safety case (SWESC) (see Glossary for definition) to demonstrate that the site is environmentally safe, and will continue to be so. The operator should keep the SWESC consistent with the waste management plan (WMP) (see Requirement R4 and Chapter 7). The SWESC needs to be maintained until the site is released from RSR (see Figure 4). The SWESC should demonstrate that the health of members of the public and the integrity of the environment will be adequately protected, both before and after release from RSR. This chapter gives information on how to establish and maintain a SWESC and on what it should contain.

6.1.2 The operator of a nuclear site should maintain a SWESC proportionate to the radiological, and any associated non-radiological, hazards that the operator's decommissioning and clean-up plans are intended to reduce or remove, and to those that will remain on or adjacent to the site when all planned operations involving radioactive substances are complete. A simple SWESC may be adequate for a site at which it can be demonstrated straightforwardly that only very low concentrations or quantities of radioactivity need to be managed. A more complex SWESC may be needed for a site where there is contamination of ground or groundwater by radioactivity, and/or where the operator proposes to dispose of radioactive waste on-site.

6.1.3 To ensure that an appropriate level of effort is put into producing a SWESC that is proportionate to the hazards involved, an operator may wish to adopt a step-wise approach to its development. An initial screening assessment of the likely impacts of any hazards remaining on or adjacent to the site could be used to inform early discussions between the operator and the environment agency, which in turn could be used to guide the development of subsequent versions of the SWESC.

6.1.4 Where a site already has a dedicated radioactive waste disposal facility, or the operator proposes to construct such a facility, environment agencies' guidance regarding near-surface disposal facilities (Environment Agency et al 2009) will apply to that facility, including the requirement to produce a facility-specific environmental safety case (ESC). In such a case the SWESC will need to take account of the risks assessed in the facility-specific ESC (see Figure 5).

6.2 General considerations

What should the SWESC demonstrate?

6.2.1 The SWESC should demonstrate a clear understanding of the site in its operational state, including during decommissioning and clean-up, during the period leading up to the site reference state and during the subsequent evolution of the site. The SWESC should be designed to demonstrate consistency with the principles set out in Chapter 4 of this document and that the management, radiological and technical requirements set out in Chapter 5 are met. The principles and requirements provide for protection of members of the public and the environment from radiological and non-radiological hazards, both during the period of RSR and subsequently. The SWESC needs to demonstrate that the site will comply with all the requirements set out in Chapter 5 both now and in the future.

6.2.2 The SWESC should include an environmental safety strategy supported by detailed arguments to demonstrate environmental safety. The environmental safety strategy should present a top level description of the fundamental approach taken to demonstrate environmental safety. It should include a clear outline of the important environmental safety arguments and say how the major lines of reasoning and underpinning evidence support these arguments.

6.2.3 The SWESC should demonstrate, using a structure based on clear linkages, how the environmental safety strategy is supported by the detailed arguments and how the arguments are supported by evidence, analysis and assessment. Internal consistency within the SWESC needs to be established and maintained.

6.2.4 The SWESC should explain how uncertainties have been considered and will be managed in the future and demonstrate that there can be confidence in the SWESC notwithstanding the uncertainties that remain. It should also demonstrate that potential biases and their effects on the SWESC have been identified and eliminated or minimised.

6.2.5 Everything significant that is claimed or assumed in the SWESC should be supported by evidence that is comprehensive, robust, and suitable. It may be difficult at the outset to determine in full which claims or assumptions are significant. The operator may find it useful to discuss the significance of various claims and assumptions with the environment agency, as development of the SWESC proceeds.

What should the SWESC include?

6.2.6 The SWESC should describe all aspects that may affect environmental safety, including the geology, hydrogeology and surface environment of the site, the characteristics of any remaining contamination and on-site disposals including any relevant engineering details.

6.2.7 To an extent appropriate to the complexity of the site and the radiological hazards to be managed, the SWESC should make use of multiple lines of reasoning based on a variety of evidence, leading to complementary environmental safety arguments. The evidence may be both qualitative and quantitative, supported where appropriate by robust numerical analyses. The reasoning and assumptions should be clear and the evidence supporting them traceable.

6.2.8 The SWESC should include quantitative environmental safety assessments for both the period of RSR and afterwards. These assessments will need to extend into the future sufficiently beyond the site reference state to provide reasonable confidence that radiological risks have peaked (for example, taking into account any delayed releases of activity from an engineered disposal facility) or until the uncertainties have become so great that quantitative assessments cease to be meaningful. They should show how radionuclides might be expected to move through the environment. After the site has been released from RSR and while any significant hazard remains, the SWESC should explore the consequences not only of the expected evolution of the site, but also of less likely evolutions and events. For some sites with only a small residual hazard after completion of all decommissioning and clean-up work, the risks may be so low that the case can be very simple.

6.2.9 The SWESC should describe the operator's arguments for having confidence in the case including, for example, reference to:

- the quality and robustness of the quantitative safety assessment and consideration of uncertainty;
- the quality, robustness and relevance of the other arguments and evidence presented;
- the operator's environmental safety culture and the breadth and depth of expertise and experience of individuals involved in activities supporting the SWESC;
- the main features of the operator's management system, such as planning and control of work, the application of sound science and good engineering practice, commissioning of appropriate research and development, provision of information, documentation and record-keeping, and quality management (see Requirement R5).

What should the SWESC achieve?

6.2.10 The SWESC should describe and substantiate the level of protection provided both during the period of RSR and afterwards. It should describe the site reference state and specify the time by which that state will be reached. It should be sufficiently comprehensive and robust to provide adequate confidence in the environmental safety of the site taking into account:

- the radiological and any associated non-radiological hazards that the operator's decommissioning and clean-up programme is intended to reduce or remove; and
- the radiological and any associated non-radiological hazards that will remain on or adjacent to the site when all planned operations involving radioactive substances are complete.

6.2.11 The SWESC should avoid complexity disproportionate to technical understanding and the availability of data. Peer review will be important to help assure quality. The operator should be alert to possible future changes to standards and to basic data, and should make the SWESC as robust as reasonably practicable in this respect.

How will the environment agencies consider the SWESC?

6.2.12 We shall consider the SWESC against the principles and requirements of this document. Quantitative assessments are likely to be important to our consideration, but regulatory acceptance of the case will ultimately be based on judgement. The quantitative and qualitative assessments provided in the SWESC will aid the judgements we make.

Maintaining the SWESC

6.2.13 The operator should maintain the SWESC in the light of factors such as developments at the site, new information, changes in legislation and Government policy, and should comprehensively review the SWESC no less frequently than every 10 years.

6.2.14 The operator will be responsible for developing and updating the SWESC at suitable intervals up to the release from RSR. The SWESC, including quantitative assessments, will need at each stage to be sufficiently detailed and comprehensive to inform and support the operator's decommissioning and clean-up programme in accordance with the waste management plan (WMP).

6.2.15 Updates to the SWESC should reflect growing knowledge about the site and should increasingly reflect the site as it is decommissioned and cleaned up in accordance with the WMP. Updates should also take into account, for example, feedback from regulators, developments in environmental safety assessment techniques, in radiological protection and in technical understanding more generally. The eventual aim will be to show that people and the environment will be adequately protected when the site reference state has been reached.

6.2.16 The operator should consider how the documentation will be structured and updated to ensure traceability and transparency. The operator should also maintain a detailed audit trail for changes to the SWESC and documentation.

Presenting and preserving the SWESC

6.2.17 The operator will need to secure and maintain the confidence of local interested people, communities and organisations by presenting the SWESC in a way that people will understand. Different styles and levels of detail are likely to be needed to present the SWESC to different audiences, but these should be consistent in referring to the same fundamental arguments.

6.2.18 The operator will be responsible throughout the period of RSR for preserving the SWESC documentation and all relevant records and providing access to these by interested people (see also Requirement R14).

Other uses for the SWESC

6.2.19 The SWESC should be used to help specify the WMP and decommissioning and clean-up programme. Operational decisions and practices should be consistent with the SWESC.

6.2.20 The SWESC will provide an input to deriving site-specific regulatory limits and conditions. It may also help to guide the environmental monitoring programme for the site and the surrounding area.

6.2.21 ONR has indicated that the SWESC may provide a suitable location for the safety cases that organisation requires, provided that it can be clearly identified as such, and meets the requirements of ONR guidance.

6.3 Additional considerations

6.3.1 Below, we provide further information on aspects we consider are particularly important in preparing a SWESC.

Multiple lines of reasoning and complementary environmental safety arguments

6.3.2 For assessments covering times after the permit has been surrendered, our main environmental safety standard is a risk guidance level (Requirement R7). We shall expect the operator to provide one or more quantitative assessments aimed at calculating risk, which can then be compared to the risk guidance level, as an important part of the SWESC for these times. However, quantitative risk assessments – even with appropriate treatment of uncertainties (see below) – may not be sufficient on their own to establish the SWESC.

6.3.3 Where environmental safety needs to be assured over long timescales, multiple lines of reasoning based on a variety of evidence may be needed, leading to

complementary environmental safety arguments. In the overall SWESC, such complementary arguments need to be brought together in a structured way.

6.3.4 Examples of environmental safety indicators that might be used to strengthen the SWESC include radiation dose, radionuclide flux, radionuclide travel times, environmental concentration and radiotoxicity. Where the radiological hazard warrants it, the operator should provide a wide range of information relating to such indicators, for example:

- assessments of the concentrations in the accessible environment of radionuclides and comparison of these with naturally occurring levels of radioactivity in the environment;
- where appropriate, assessment of collective radiological impact (as a measure of how widespread any significant increase in risk may be as a result of radioactivity released into the accessible environment) - however, see paras 5.3.83 and 5.3.84;
- unifying statements that aim to place in context the different items of information that contribute to assuring environmental safety.

Managing uncertainties

6.3.5 Managing uncertainties is a necessary and important part of establishing the SWESC, and will need to be addressed each time the SWESC is updated. Where necessary the operator may need to account for uncertainties explicitly, analyse their possible consequences and consider where they may be reduced or their effects lessened or compensated for. Uncertainties themselves are not obstacles to establishing the SWESC, but they do need to be properly considered and included in the structure of the SWESC as appropriate.

6.3.6 The operator will need to demonstrate that the SWESC, for both the period of RSR and afterwards, takes adequate account of all uncertainties that have a significant effect on the SWESC. This will mean establishing and maintaining:

- a register of significant uncertainties;
- a clear forward strategy for managing each significant uncertainty, based on considering, for example, whether the uncertainty can be avoided, mitigated or reduced, and how reliably it can be quantified.

6.3.7 The operator should explain the significance of uncertainties important to the SWESC, in a way that people will understand. This material could form part of the environmental safety strategy (see para 6.2.2). The relevant environment agency will provide its own view on the operator's statements.

6.3.8 As explained under Requirement R7, an important distinction can be made between two types of uncertainty: those that can reliably be quantified and those that cannot. Natural variability and statistical inexactness belong to the first type (capable of being assessed statistically), while problems of data relevance, lack of understanding of processes, and uncertainty about future human behaviour belong to the second type. Uncertainties of the second type are no less real and important than those of the first type and both types need to be taken into account in the SWESC.

6.3.9 The two extreme types of uncertainty described above may be considered to lie at the opposite ends of a range. When dealing in practice with a particular uncertainty

for which only limited data exist, it may be necessary to regard it as including both a quantifiable and an unquantifiable component in order to take it properly into account in the SWESC. Expert judgement (see paras below) may often play a significant part in developing approaches to handling such uncertainties.

6.3.10 The operator should follow radiological protection advice that is applicable at the time of the assessments of dose and risk (e.g. dosimetric data and the applicable risk coefficient) are carried out. Uncertainties in these areas are common to all radiological assessments and are normally left implicit. There is, therefore, no special reason to include them explicitly in assessments supporting the SWESC for a nuclear site.

6.3.11 Some uncertainties may be quantified and applied to parameter values used in quantitative environmental safety assessments. There are established methods for carrying out these calculations, and the SWESC should make clear which uncertainties have been addressed in this way.

6.3.12 Some uncertainties may be managed by making simplifying deterministic assumptions based on reasoned arguments. Because processes that take place in a natural environment are liable to be highly complex, some simplifications in environmental safety assessments are likely to be unavoidable. As part of the SWESC, the operator needs to show that any simplifications used either have an insignificant effect on the outcome of the assessment, or have a conservative effect (i.e. do not lead to the effects being underestimated).

6.3.13 It may be inappropriate to quantify some uncertainties because relevant and reliable data are not available. If these uncertainties are important to the SWESC, they may be treated by a series of risk assessments, in each case making deterministic assumptions and exploring the effects of varying these. Important examples include qualitatively different sequences of events that could occur in the future (for example different evolutions of climate or landscape), and alternative conceptual models that are each consistent with the data available but that produce different projections of future environmental performance.

6.3.14 In some circumstances, where few or no relevant data can be gathered, a ‘stylised’ approach may be taken, in which arbitrary assumptions are made that are plausible and internally consistent but tend to err on the side of conservatism. The evolution of the biosphere and human intrusion provide examples of where it may be appropriate to use a stylised approach. If a stylised approach is used for modelling the site, or part of the site, the operator needs to take care that the use of this approach does not distort the modelling of the rest of the system such that important properties of other parts of the system are obscured in the overall model.

6.3.15 Because there may be various uncertainties in the SWESC for times after the site reference state has been reached that cannot reliably be quantified, the results of quantitative environmental safety assessments in the form of calculated risks are likely to be only broad indicators of environmental safety. This is one reason why the SWESC may need to be based on multiple lines of reasoning and on a variety of evidence, leading to complementary environmental safety arguments.

6.3.16 Uncertainties are not confined entirely to times after the site reference state has been reached. The design and implementation of the WMP and the decommissioning and clean-up programme for a nuclear site all contain their own uncertainties. These are caused, for example, by data not yet gathered, work not yet carried out and decisions not yet taken. These types of uncertainty will be resolved

as the decommissioning and clean-up programme progresses and the WMP is executed. Meanwhile, however, they can affect environmental safety projections in the SWESC for both the period of RSR and afterwards, and need to be managed alongside all other uncertainties. The SWESC will need to be updated as these uncertainties are resolved, taking into account, for example, data on the site as characterised, in place of data assumed during planning.

Modelling studies and confidence-building

6.3.17 Modelling studies are likely to make up an important part of the quantitative site wide environmental safety assessment; however, they should be proportionate to the hazards and appropriate to the available data. They may also contribute to or support complementary arguments based on alternative lines of reasoning. As well as the results of the studies, the operator will need to provide details of the models and methodologies used, including any assumptions and model validation.

6.3.18 The general aim of modelling studies will be to help in understanding the characteristics and behaviour of the overall site. However, in order to contribute usefully to the SWESC, each specific set of modelling studies will need to have more specific defined and documented objectives:

- modelling objectives should take account of the decisions that the results are intended to support; the selected approach should be driven mainly by the modelling objectives, and not by the availability of models or software or by considering what models or software were used previously (unless there is an overriding need for consistency);
- modelling objectives should be defined in terms of what can be accomplished with the available data. Complex models should not be developed if there is not enough data to support them;
- the objectives should be reviewed throughout the modelling process.

6.3.19 In cases where there are likely to be extensive modelling studies, we encourage the operator to consider discussing the modelling objectives at an early stage with the relevant environment agency.

6.3.20 The operator will need to carry out a systematic programme of work to build confidence in the modelling. This will include interpreting raw data and developing and testing conceptual, mathematical and computational models. The process of building confidence in a model for its intended purpose is iterative and progressive. In some cases where long timescales are modelled to support the SWESC it may not be possible to have meaningful direct validation by comparing model outputs with observations. The measures taken in a confidence-building programme should include:

- systematic approaches to model building and consideration of alternative models;
- iteration between model building, quantitative assessments and data collection;
- good communication between modellers (including those developing and using models), suppliers of data (including those planning research or data collection and those actually making observations) and those using modelling results;
- continuing peer review of model development;

- rigorous quality assurance of all modelling activities and associated data handling, including controls over changes to models and data and a detailed audit trail.

6.3.21 Models and associated parameter values should, to the extent possible at the time of the assessment, be site-specific. The use of generic or default data instead of site-specific data will need to be supported by considering the effect that this has on the SWESC: in general the use of such data should be shown not to lead to an underestimation of the effects. Using generic models and parameter values may be more acceptable in the early stages of developing the SWESC or where the radiological hazard is particularly low.

6.3.22 In some areas, there may be a number of alternative credible interpretations of the data. Thus, no one conceptual model of the system can be regarded as uniquely valid. Where considering only one preferred conceptual model could significantly underestimate the actual overall uncertainty, we shall expect the operator to show that the SWESC is not unduly sensitive to alternative interpretations or conceptual models.

6.3.23 Area by area, the operator will need to judge when it will be sensible to end the programme of building confidence in the modelling. The operator will need to provide us with the basis for these judgements.

6.3.24 Computational models need to be used in an appropriate manner. In particular, the input parameters will have ranges of values outside which the results from a model cannot be relied on. The operator needs to provide a statement of the range of validity of each model used, together with appropriate evidence.

6.3.25 We recognise that models supporting the SWESC may be used to provide projections over time periods far exceeding any period for which the models have been tested against observations. Modelling projections of this nature cannot be regarded as predictions, but as assessments provided to support judgements about environmental safety. Quantitative modelling projections should not be made for times so far into the future that uncertainties render the modelling results meaningless.

Use of expert judgement

6.3.26 Expert judgement is essential in gathering and interpreting evidence and applying it to construct and use the qualitative and quantitative models that will support the SWESC. Much expert judgement is held in common and is fundamental to standard approaches. As far as possible, the operator should use standard approaches to establish the SWESC, thus relying on this kind of expert judgement.

6.3.27 There may be parts of the SWESC, however, where expert judgement that is not held in common will be used to complement or interpret evidence or to compensate for data gaps. Such judgement may be made in an informal fashion or may be elicited using more formal structured procedures, as appropriate to the situation. Where this type of expert judgement is used, the operator should, to an extent proportionate to the significance of the judgements to the SWESC: explain the choice of experts and method of elicitation; document explicitly expert judgements that have been made and the reasons given by experts to support their judgements; and take and document reasonable steps to identify and eliminate or minimise any biases resulting from the use of expert judgement and/or the elicitation methods used.

Environmental safety standard before the release from RSR

6.3.28 Before the release from RSR (i.e. during decommissioning and clean-up and implementation of the WMP) and during any subsequent period of continuing operator control, Requirement R6 (dose constraint) applies because the site is under the operator's control. Many of the issues associated with demonstrating compliance with the dose constraint are the same as at other times during operation. The state of the site, however, is progressively changing during this period, rather than resembling a steady state as during operation. During decommissioning and clean-up and implementation of the WMP, the SWESC needs not only to demonstrate the acceptability in environmental safety terms of the present state of the site, but also to anticipate future site states. Without this forward-looking component, the SWESC might demonstrate an acceptable current state but conceal unacceptable future states.

6.3.29 For instance, an operator might propose putting parts of the site into a quiescent state for an extended period of time to gain the benefits of radioactive decay. An example of this might be putting a defuelled reactor into 'safestore' for an extended period. In this case, the SWESC would need to demonstrate not only that people and the environment are protected during the quiescent period, but also that they will continue to be protected when decommissioning and clean-up activities resume afterwards.

Environmental safety standards that apply after release from RSR

6.3.30 The SWESC, together with the evidence that supports the claims made in the SWESC, will provide a basis for release from RSR. When the permit is surrendered, the relevant environment agency will relinquish regulatory control and no further operator control of the site can be presumed. Hence Requirement R7 (risk guidance level), which is forward-looking and is not dependent on continuing operator control, becomes relevant and Requirement R6 (dose constraint), which is dependent on operator control, ceases to apply.

6.3.31 The SWESC should demonstrate either that the site will be available for unrestricted use after the permit is surrendered, or that it will be available for restricted use with a suitable body exercising control until the site reference state is reached. If the SWESC shows that the site will be available only for restricted use initially, this is likely to be to allow for natural processes including radioactive decay, dilution and dispersion. In this case, the period of restricted use would be likely to require controls to limit the possible scenarios for human intrusion.

6.3.32 Natural processes of dilution and dispersion of radioactive substances in the environment will need to be taken into account. The SWESC should include suitable scenarios to assess the risks and compare the results of the assessments with the risk guidance level under Requirement R7.

Groundwater

6.3.33 The requirements of the Groundwater Directive 2006 (EC 2006) will need to be taken into account in the development of the SWESC. Guidance on the application of EC 2006 to radioactive substances and to other pollutants is provided for England and Wales by DEFRA (2011) and for Scotland by SEPA (2014).

Climate change

6.3.34 The SWESC will need to take into account the potential for climate change. Possible climate change may be induced by natural processes, or by human actions affecting natural processes. There is considerable uncertainty regarding the rate, amount and even the direction of possible climate change over different timescales. So, the operator will need to consider a range of possibilities. The potential consequences of climate change include changes in rainfall patterns (which can affect watercourses and aquifers), changes in sea level, increased rates of erosion including coastal erosion, glacial cycling and glaciotectonic movements.

Human intrusion

6.3.35 We shall expect the operator to consider human intrusion as part of the SWESC in accordance with Requirement R8. Because of the obvious uncertainties in trying to predict what people might do in the future, this is likely to involve using stylised calculations as discussed above (see para.6.3.14).

Natural disruptive processes after release from RSR

6.3.36 We shall expect the operator to consider in the SWESC the possible effects of natural disruptive processes after release from RSR, in accordance with Requirement R9.

Optimisation

6.3.37 We shall expect the operator to demonstrate in the SWESC that optimisation considerations have been applied in all relevant decisions and at all relevant stages, in accordance with Requirement R10.

Environmental radioactivity

6.3.38 We shall expect the operator to consider environmental radioactivity as part of the SWESC in accordance with Requirement R11.

Protection against non-radiological hazards

6.3.39 Radioactive substances at a nuclear site may present non-radiological hazards as well as a radiological hazard. In accordance with Requirement R12, the SWESC will need to demonstrate that an adequate standard of protection is achieved for any non-radiological hazards.

Restricted uses

6.3.40 The SWESC may take account of any proposed controls to be exercised over the site or on the surrounding land after release from RSR, if it can provide assurance that these will be implemented and maintained for as long as required (see Chapter 8).

Knowledge management

6.3.41 The SWESC should not place any unreasonable reliance on the preservation of knowledge and records of the site after release from RSR even though, under Requirement R14, we expect the operator to take all reasonable steps to ensure that such knowledge and records will be preserved.

Fissile material

6.3.42 The SWESC should consider the possibility and consequence of a criticality event. However, we do not expect significant amounts of fissile material to remain at a site that has been decommissioned and cleaned up. Therefore we recognise that a simple analysis should be sufficient to demonstrate that such an event will not occur.

7. Waste management plan (WMP) (Requirement R4)

7.1 Introduction

7.1.1 An operator should establish and maintain a waste management plan (WMP) (see Glossary for definition) to manage the programme of disposals of radioactive waste until no further work involving radioactive substances is required to achieve the site reference state (see Figure 4). The operator should keep the WMP consistent with the site wide environmental safety case (SWESC) (see Requirement 3 and Chapter 6).

7.2 General considerations

Acceptability of the WMP

7.2.1 The WMP will be acceptable only if the SWESC demonstrates that any proposals for the disposal of radioactive waste on site are consistent with **all** our requirements. That is to say, any disposals on site must not prevent attainment of an acceptable site reference state within 300 years after all work involving radioactive substances has ceased.

7.2.2 We will only authorise the disposal of radioactive waste on-site if the operator demonstrates, through the WMP and the SWESC, that such disposals are both safe and optimised.

What should the WMP demonstrate?

7.2.3 The WMP should demonstrate that any proposed on-site disposals of radioactive waste are optimised, and that the plan itself is consistent with the SWESC. (In turn, the SWESC should demonstrate that the planned disposals are safe, that is the doses and risks presented by those disposals are consistent with our quantitative and qualitative requirements.)

7.2.4 The WMP should also demonstrate that all the existing and prospective radioactive waste on site identified in the WMP is in a state that is adequately controlled, i.e. that secondary wastes are not being, and will not be, unnecessarily created and that there is not, and will not be, any avoidable spread of radioactive contamination or associated chemical pollution in the ground and groundwater. This applies to all wastes, whether held in engineered stores, buried in situ, awaiting retrieval or in open stockpiles.

7.2.5 The WMP should demonstrate an integrated approach to the management of all wastes, both directive wastes and radioactive wastes, over the lifetime of the facility (see Figure 8).

What should the WMP include?

7.2.6 The WMP should include all forms of radioactive waste, including:

- existing waste;
- waste anticipated to arise; and
- waste in situ.

7.2.7 The WMP should take account of both the radiological and non-radiological hazards of the waste.

7.2.8 The WMP should identify any past disposals of radioactive waste on site, and all proposed disposal routes over the remaining lifetime of the facility. Disposal routes may include:

- disposal by transfer off site;
- disposal by emplacement on site, e.g. into an on-site waste disposal facility or for void filling; and
- disposal by leaving waste in situ.

How will the environment agencies consider the WMP?

7.2.9 We shall consider a proposal from an operator to dispose of radioactive waste under the WMP to satisfy ourselves that, in the context of all waste disposals for the site:

- it is acceptable in terms of current and future doses and risks to people and the environment; and
- it represents an optimised approach to disposing of the waste concerned.

7.2.10 To satisfy ourselves on these points the SWESC will be an important input to our considerations. The WMP and the SWESC will thus need to be up to date and consistent with one another.

Maintaining the WMP

7.2.11 The operator should maintain the WMP in the light of factors such as developments at the site, new information, changes in legislation and Government policy, and should comprehensively review the WMP no less frequently than every 10 years.

7.2.12 Site-specific developments necessitating a review may include, for example:

- Achievement of significant milestones in progress towards the site reference state, as demonstrated by the SWESC;
- New information about sources of radioactivity in the ground or groundwater, for example as a result of better characterisation of known sources or identification of new sources;
- New information about the migration of activity in the ground and groundwater, affecting radiological doses to people or the environment;
- The requirement to maintain currency and best practice; and
- The requirement to maintain consistency with the SWESC.

7.2.13 If the WMP is revised we expect the operator to declare to us any changes that materially affect the SWESC.

7.2.14 The operator should also maintain a SWESC (see Requirement R3 and Chapter 6) that demonstrates how the WMP is consistent with bringing the site to a condition at which it can be released from radioactive substances regulation at an appropriate time and with achieving the site reference state no later than 300 years after all work involving radioactive substances has ceased.

7.2.15 We accept that an operator may not initially have the necessary information to identify and characterise waste and select optimised disposal routes for all wastes that might arise. In such a case the operator should demonstrate that it has a programme of work that will lead to the timely identification and characterisation of all the radioactive waste on site, and to the selection of optimised disposal routes and the implementation of appropriate subsequent actions.

What is radioactive waste?

7.2.16 "Radioactive waste" is very broadly defined such that any substance or article that has been used by the operator for the purpose of the undertaking will become waste when no longer used, and will be radioactive waste if it contains or is contaminated with radioactivity above the out of scope values (RSA 93 and EPR 2010).

7.2.17 Radioactive waste may include, but is not limited to, redundant objects and structures such as buildings, vaults, ponds, ducts, drains, sumps, or pipes (whether at, above, or below ground level), rubble or scrap resulting from the dismantling or demolition of such objects and structures, and waste resulting from clean-up of ground or groundwater contaminated by radioactivity.

7.2.18 Radioactive waste is subject to different legislation from non-radioactive waste. RSR legislation in the UK transposes Directive 96/29/Euratom (EC 1996), whose primary aim is the protection of people from ionising radiation. UK legislation governing non-radioactive waste transposes Directive 2008/98/EC (EC 2008). This is commonly referred to as the "Waste Framework Directive", and the non-radioactive waste to which it applies as "directive waste". The Waste Framework Directive has two primary goals, namely (i) protection of people and the environment from waste while (ii) promoting sustainable development and conserving natural resources, through the establishment of a market in recovered waste. Figure 8 illustrates the interaction between RSR and conventional waste management.

7.2.19 The exemption for "land (in-situ) including unexcavated soil and buildings permanently connected to land" in the Waste Framework Directive does not apply to radioactive waste and is not replicated in RSR legislation. This means that:

- any building or structure becomes radioactive waste when no longer used, and if containing or contaminated with radioactivity above the out of scope values; and
- authorisation will be required under RSR before these can be left in situ permanently.

7.2.20 Ground or groundwater contaminated with radioactivity, for example from past leaks, is not radioactive material or waste, provided it remains in situ. However, if remediation work generates waste, then that will be radioactive waste, if it contains activity above the out of scope values.

Integrated waste management

7.2.21 We expect operators to demonstrate strategic planning for the management of all wastes, ie both radioactive and non-radioactive (or "Directive") waste in an integrated way, i.e. in accordance with an integrated strategy, to address the various statutory, Government policy and ONR requirements covering these wastes. Such planning should take into account all current and anticipated future arisings of waste, including the management of material that will become waste in the future, and their radiological and non-radiological properties. Operators should thereby

maintain a clear strategic overview of how they intend to manage the generation and disposal of waste over the lifetime of the facility. This should include the management of the generation and disposal of waste associated with planned work that will in due course bring the site to a condition at which it can be released from radioactive substances regulation.

7.2.22 Such an integrated approach is necessary to ensure that statutory requirements are addressed in an integrated and efficient way and to ensure that people and the environment are properly protected against both the radiological and conventional properties of the waste. The WMP needs to be consistent with the integrated waste management strategy.

7.2.23 Such planning should seek to ensure that decommissioning and clean-up are carried out so as (a) to minimise waste generation and (b) to facilitate the management and disposal of those wastes that are generated in accordance with legislation and Government Policy. For radioactive wastes, this includes considerations such as:

- the segregation of waste to maximise the volume of waste that is not radioactive waste and minimise the volume of radioactive waste;
- the appropriate use of exemptions for radioactive waste;
- for LLW, the requirements of the LLW policy in general, including the need for early solutions for waste disposal in particular;
- for wastes for which there are no immediate disposal options, how that waste will be treated and stored in a passively safe way until disposal can take place;
- for higher activity wastes, the need for operators to produce Radioactive Waste Management Cases.

Waste characterisation

7.2.24 In general, operators will need to undertake characterisation before and during waste generation and disposal, to the extent necessary to inform decision making about decommissioning and clean-up and the associated management of the generation and disposal of waste.

7.2.25 In particular, structures such as buildings, vessels and pipes are likely to be contaminated in parts that have previously been exposed to radioactive substances during operation or exposed to contamination from leaks or spills. Such contamination may be limited to the surface of impermeable structures or may have migrated into porous structures. The extent of migration may vary depending on the radionuclides present and their chemical form. The degree and nature of contamination may be very variable over such structures as a whole. In addition, parts of these structures may be difficult to access, making in situ assessment of the extent and levels of contamination difficult.

7.2.26 In such situations we expect operators to use an approach that takes into account the possibility that the structure comprises parts that may be below the out of scope values for radioactive substances and parts that are above these values, and to consider how best to achieve overall effective waste management for the structure and its constituent parts, within an integrated approach to waste management (of both radioactive and directive waste) for the site as a whole.

7.2.27 In general, it is not acceptable to average the estimated activity over the total mass of the structure and then to argue that the waste structure, as a whole, is out of scope or exempt. And in any event, the average is unlikely to be accurate having regard to the difficulty of assessing the inventory of radionuclides in buried structures. The nuclear industry code of practice (NICoP) on clearance and radiological sentencing (Nuclear Industry Safety Directors' Forum 2012) provides guidance on this subject: it does not support the concept of averaging over a structure to determine whether it is radioactive waste, exempt or out of scope.

Waste minimisation

7.2.28 Decommissioning and clean-up activities, such as retrieval of waste, decontamination, cutting and dismantling plant for removal, and demolition of buildings, have the potential to spread radioactivity more widely resulting in the generation of large volumes of lower activity wastes or the generation of "secondary wastes". Operators' decommissioning arrangements should seek to avoid and minimise the generation of such wastes.

Part III: Regulatory requirements and considerations.

8. Regulatory requirements and considerations

8.1 Introduction

8.1.1 This chapter describes the regulatory requirements and considerations regarding how operators prepare for and then obtain release from radioactive substances regulation; that is, how we expect operators to implement the requirements in this guidance over the lifetime of a site.

8.2 Overview of regulatory requirements and considerations

8.2.1 In outline, operators will need to assess, plan and undertake the work necessary to bring the site to a condition at which it can be released from RSR. This may involve disposals of radioactive waste on and off site and remediation work in relation to ground and groundwater contaminated by radioactivity. To support that work, we will require operators, under their permits, to:

a) maintain a waste management plan (WMP) that identifies all current and prospective disposals of waste to attain the condition at which can be released from regulation; and

b) maintain a site wide environmental safety case (SWESC) that informs the work necessary to bring the site to that condition and assesses progress towards the condition.

8.2.2 Operators will need prior authorisation to dispose of waste on site, including disposing of waste in situ. We expect operators to seek authorisation for such disposals based on the WMP and the SWESC at the earliest practicable opportunity.

8.2.3 On completion of all planned work involving radioactive substances, either the site may already be suitable for unrestricted use, or the operator may seek to rely on a period of restricted use until radioactive decay and other attenuation processes allow unrestricted use. If the operator proposes the latter, the operator's SWESC will need to show that the controls proposed will be sufficient to meet the requirements for as long as necessary.

8.2.4 When applying for release from RSR regulation, the operator will need to show through the SWESC that the site is either already suitable for unrestricted use, or that there are adequate controls in place to maintain any necessary restrictions after release until the site is suitable for unrestricted use.

8.2.5 The overall progression towards release, the relationship between the WMP and SWESC, and the potential timings of release are shown in Figures 2 and 4. These are indicative only. The timings for the preparation of the WMP/SWESC and planned works, etc., are site-specific and for existing sites will necessarily reflect their current position on the timeline shown in Figures 2 and 4. In addition, different parts of a site may be at different stages in the lifecycle, leading potentially to some parts of a site being released from RSR earlier than others.

8.2.6 This chapter describes requirements and considerations in relation to

- WMPs and SWESCs;
- the on-site, including in-situ, disposal of radioactive waste;

- applications for release from RSR regulation.

8.3 WMP and SWESC

8.3.1 A nuclear site operator will normally hold a single RSR permit that will require the operator to maintain (that is develop and keep up to date) a WMP (Requirement R4) and a SWESC (Requirement R3). The WMP and SWESC should together demonstrate, using available evidence and conservative arguments and assumptions, that the proposed future disposals will enable the site reference state to be achieved in due course, i.e. that the totality of radioactive waste disposals and radioactive contamination remaining on and adjacent to the site will, with unrestricted use of the site, meet our requirements for protection of people and the environment.

8.3.2 "Site" in the SWESC includes the maximum extent of the operator's premises and may also need to take account of other significant adjacent sources of radiological exposure, such as contamination outwith the premises and any adjacent nuclear site(s). The land area assessed through the SWESC does not reduce where there has been partial release from RSR, but remains fixed until full and final release of the site from RSR. We take this approach because the dose limits and constraints in the legislation and our dose and risk based principles and requirements relate to all sources of exposure to members of the public including sources on adjacent sites or land and on parts of the premises previously released from RSR.

8.3.3 We refer to WMP and SWESC for convenience; we do not require operators necessarily to produce specific documentation (other than, as a minimum, 'head' or signposting documents). We encourage operators to take an integrated approach to meeting all relevant requirements, including those that relate to non-radioactive waste and those of other regulators, such as ONR. The WMP and SWESC, however structured, must ensure that all the relevant information is kept, and the demonstrations made in a clear, comprehensive and integrated manner for the site as a whole, and in a manner compliant with the permit conditions. If the operator is making use of information set out in other documentation, then it must be clear which specific information is being relied on and for what purpose, and how the information makes the necessary demonstrations.

8.3.4 We expect operators to prepare the WMP and SWESC at the earliest practicable opportunity and to ensure that they are consistent with wider strategies and plans, such as the site decommissioning plan, to show the pathway towards eventual release of the site from RSR. Operators should have regard to the requirements of this guidance when planning, designing, constructing and operating new facilities.

8.3.5 Operators will need to engage with the relevant environment agency and with stakeholders, in the production of the WMP and SWESC (Requirement R1 & Requirement R2).

8.3.6 The WMP and SWESC should take into account all planned work associated with bringing the site to a condition at which it can be released from RSR, whether that work is continuous or not, including periods such as "care and maintenance", during which decommissioning is deferred. In particular where a period or periods of deferred decommissioning are proposed, the WMP and SWESC must address the planned work necessary after those periods to bring the site subsequently to a condition at which it can be released from RSR.

8.3.7 All proposed disposals of radioactive waste set out in the WMP, whether on-site or off-site, will require authorisation in the normal way and are subject to the usual considerations. The plan cannot be considered to be feasible until and unless such authorisation is granted. The authorisation of disposals is discussed further in the next sub-section. We expect the WMP and SWESC to be comprehensive in their coverage at the time of application for a variation to dispose of radioactive waste, but we recognise that they may change.

8.3.8 The WMP and SWESC, as living documents, need to be consistent with each other, as they evolve with time. As decommissioning and clean-up proceed, implementation of the WMP will generate detailed records such as those for any on-site disposals. Understanding of the risks presented by disposals and contamination remaining on or adjacent to the site will improve, and hence uncertainties in the SWESC will tend to diminish.

8.3.9 The operator will need to maintain and modify both the SWESC and the WMP in the light of factors such as developments at the site, new information, changes in legislation and Government policy, and should comprehensively review them no less frequently than every 10 years . Crucially, the SWESC should be regularly reviewed and as necessary updated, to reflect the extent to which the WMP has been implemented. Likewise, the WMP should be reviewed and, steered by the SWESC, revised as necessary to ensure that it remains on track to achieve the site reference state at the due time.

8.3.10 Once an operator has completed all planned work involving radioactive substances, that is the WMP has been fully implemented, the risks to people and the environment presented by any remaining radioactive substances (in the form of residual contamination, or authorised on-site disposals), may be sufficiently low to allow for immediate unrestricted use of the site. But where the risks presented by the radioactive substances remaining on or adjacent to the site do not allow immediate unrestricted use, an operator may propose a period of restricted use, as part of an optimised plan for returning the site to a state where no control of the site is necessary for the purpose of protecting people and the environment.

8.3.11 If an operator wishes to make such a proposal, the operator will need to show in the SWESC that the controls provided for this period will be sufficient to meet the relevant requirements and that the arrangements for applying the controls can be relied on to be implemented as planned and maintained as long as necessary.

8.3.12 A proposal for a period of restricted use may need to include provisions for site surveillance with scope for remedial work if needed, a programme of environmental monitoring, arrangements for the preservation of records, and other controls. It will need to be supported by evidence that these provisions can be relied on to remain effective throughout the claimed period of time. Because of the major social changes that may accumulate over long periods of time, it is unlikely that the environment agencies would accept a claim for a period of restricted use lasting longer than 300 years from the end of planned operations involving radioactive substances. In that event we would expect the operator to undertake further work so as to reduce the proposed period of restricted use to less than 300 years.

8.3.13 If an operator proposes a period of restricted use for longer than several decades, issues such as site ownership, surveillance of the site and compliance with RSR permit conditions will be important considerations in our decisions regarding whether to accept that proposal.

8.3.14 The degree and extent of controls required will depend upon the risks presented by the radioactive substances remaining on or adjacent to the site, and are likely to change as those risks diminish with time. Figure 2 illustrates how such controls may change between the time that all planned works have ceased and the time at which the site reference state is attained. It is likely that the controls will initially be provided by the site operator's management arrangements for ensuring compliance with a RSR permit, and those will be regulated by the relevant environment agency. As the risks diminish, so will the degree and extent of controls, which may eventually be managed and regulated by parties other than the operator and the environment agency. The period of restricted use we describe here provides a function similar to "institutional control" or "institutional oversight", terms often used in international literature. We have chosen not to use this terminology here as definitions and understanding can vary. However, many of the concepts and intentions discussed above have similarities to the ideas presented in the literature that makes use of these terms.

8.3.15 By the time the operator submits an application for release of the site from RSR, work under the WMP should be complete and the SWESC should be in its final form. Uncertainties should have been reduced to levels requiring no further action.

8.4 Authorisation of specific disposals

8.4.1 Most nuclear sites are permitted to dispose of radioactive waste by transfer off site to other "waste permitted persons". However, nuclear sites are not routinely permitted to dispose of radioactive waste to land on site.

8.4.2 Operators cannot emplace, or leave buried in situ, radioactive waste until and unless authorised to do so under RSR. An operator who wishes to do so should apply for a variation to the permit at the earliest practicable opportunity. An application for such a variation should be accompanied by:

- a WMP setting out the proposed disposals, including options assessments demonstrating that these represent the optimised options; and
- a SWESC demonstrating that, after implementation of the WMP, the site will reach a condition consistent with our requirements for release from RSR, such that the site reference state will be achieved at an appropriate time.

8.4.3 An operator will need to seek subsequent variations if it proposes changes to the on-site waste disposals set out in the WMP.

8.4.4 Where disposal is to a dedicated on-site specialised waste disposal facility, we may authorise this separately where appropriate.

8.4.5 Figure 1 illustrates a range of possibilities for the disposition of radioactivity from a decommissioning nuclear site. It shows examples of the disposal of radioactive waste, on-site or by transfer off site and, for completeness, includes ground/groundwater contaminated by radioactivity and left in situ.

Optimisation of radioactive waste disposal

8.4.6 In all cases operators should undertake an assessment of all reasonably practicable options for the management and disposal of radioactive solid waste, including waste in situ, as part of identifying the optimised disposal route. Where the operator wishes to dispose of waste on site, including leaving waste in situ, the operator should demonstrate that this:

- is an optimised disposal option for that waste in the context of the site as a whole;
- is consistent with bringing the site to a condition at which it can be released from RSR; and
- can be done in accordance with the relevant principles and requirements in our guidance, as demonstrated through the SWESC and an ESC for a dedicated disposal facility where required.

8.4.7 Operators should have regard to the considerations set out in the low level waste (LLW) policy (DEFRA 2007). In general, these considerations also apply to waste having higher levels of activity, such as buried structures with localised areas of higher contamination.

8.4.8 Operators should also manage radioactive waste in relation to its non-radiological properties to standards consistent with that for non-radioactive waste and should therefore have regard to these in their options assessments. This is likely to be particularly relevant to demolition or excavation waste, where waste may be chemically and physically similar to non-radioactive waste, differing only by having elevated radioactivity content.

Taking advantage of radioactive decay

8.4.9 An operator may wish to take advantage of radioactive decay in optimising the management of radioactive waste, including its eventual disposal. The operator will need to declare any such intention in the WMP, and demonstrate how this is the optimised management option for the waste. Any such arguments will also need to ensure that the radioactivity is adequately controlled to minimise migration into or through the environment during the period of radioactive decay.

8.4.10 Proposals for taking advantage of decay and hence delaying disposal will only be acceptable to the environment agencies where, at the end of the decay storage period, the intention is to remove the waste and transport it for disposal at another location. Where there is no intention by the operator to remove waste after a period of decay storage, we regard this as a de facto decision to dispose of the waste in situ while it is still radioactive waste. We shall expect the operator to declare this intention in the WMP and to apply for authorisation to dispose of the radioactive waste.

8.4.11 If the waste has decayed to out-of-scope levels at the time of any removal and transport, it will be subject to environmental legislation applicable to directive waste and will need to be dealt with accordingly.

On-site disposal of radioactive waste in a dedicated facility

8.4.12 An operator may seek to dispose of radioactive waste to a dedicated on-site facility (see Figure 1. B). For full guidance on the environment agencies' requirements for authorisation of such a facility, operators should refer to our NS-GRA (Environment Agency et al 2009).

8.4.13 Such a dedicated radioactive waste disposal facility will require its own ESC. The operator should take full account of the risks assessed in the facility-specific ESC within the SWESC for the site as a whole.

On-site disposal of buried waste in situ

8.4.14 An operator may seek to dispose of radioactive waste, such as a buried object or structure, by leaving it in situ permanently (see Figure 1. C & D). As with all radioactive waste, an operator must apply for a variation to the site permit before such disposals can be authorised.

8.4.15 We consider it imperative that the operator makes a timely assessment of the optimised disposal option for buried radioactive waste, i.e. whether to dispose of it in situ, or to retrieve and dispose of it in some other manner. The operator should therefore set out the intent in the WMP at the earliest opportunity.

8.4.16 Unless and until we authorise an in situ disposal, we will normally regard buried waste as waste awaiting retrieval and disposal. We will need to be satisfied that:

- the operator intends to retrieve and dispose of the waste and that that intent is feasible; and
- the waste will not lead to unacceptable impacts before or after retrieval.

8.4.17 In this context we regard "feasible" as including legal considerations in general and RSR legislation and policy in particular. That is, to be feasible, proposals should in general meet the requirements of RSR legislation and the objectives of Government policy, as well as being implementable in practical terms.

8.4.18 Where there are substantial reasons to leave waste in place for long periods of time prior to its retrieval, operators must set out the optimised timescales for this in their WMPs. In determining those timescales, the operator must consider issues such as the potential for migration of radioactivity from the waste into the environment before retrieval and physical changes to the waste affecting the ability to retrieve it.

8.4.19 We may conclude that an operator has in effect disposed of waste in situ where:

- the operator has not declared any intent to retrieve the waste in the WMP; or
- we are not satisfied that any stated intent to retrieve the waste is feasible or will be implemented.

8.4.20 We will take appropriate enforcement action for any unauthorised disposal of radioactive waste.

On-site disposal of radioactive waste for a purpose

8.4.21 An operator may seek to dispose of radioactive waste on site for a purpose (see Figure 1. E, F & G) such as:

- making land safe, for example by filling voids;
- constructing roads, tracks and hard-standing; or
- constructing bunds, barriers or screens.

8.4.22 An operator proposing to dispose of radioactive waste for such a purpose, in addition to demonstrating that the disposal is in accordance with the requirements summarised at 8.4.2, should also demonstrate that such waste has a suitable physical and chemical specification and averts, or reduces, the need to import to the site, material that would otherwise be needed for that purpose. All such works must

be done in accordance with relevant legislation and engineering standards and good practice.

8.4.23 The operator also needs to take account, in a proportionate manner, of additional relevant considerations in the NS-GRA, in particular:

- NS-GRA Requirement R12 : the design, construction, operation and closure of the facility (whether engineered or natural); and
- NS-GRA Requirement R13: waste acceptance criteria (in relation to the nature of waste to be emplaced).

8.4.24 There is no equivalent in RSR to the concept of "recovery", as used in the Waste Framework Directive. Radioactive waste disposed of for a purpose remains radioactive waste until the site on which it was disposed of is released from RSR.

Management of waste awaiting disposal

8.4.25 Where radioactive waste is stored in a dedicated storage facility, the waste should be packaged and the facility designed and operated to prevent escape of radionuclides and to minimise waste from eventual decommissioning and demolition of the facility.

8.4.26 Where the proposal is to leave waste in situ for a period of time or in open stockpiles (as might be the case for demolition rubble) the operator will need to demonstrate that any migration of radioactivity into the environment during storage is acceptably low. Such a demonstration will require characterising the waste adequately in terms of its radionuclide content and physical and chemical form so that the storage period and the potential magnitude and effect of migration can be assessed in the SWESC. The stored waste may also require monitoring for migration.

8.5 Release from RSR

8.5.1 An operator may apply for release from RSR for part or all of a nuclear site. The detailed application process differs between Scotland and England and Wales and is not described in this guidance. The following describes the substantive approach to release which is common across the UK.

8.5.2 Operators may seek release of the site as a whole, or in steps whereby parts of a site are released before final release of the remaining part of a site. Decisions on the timing of applications for release and their extent, that is whether for partial or full release, are for the operator to make, and not for the relevant environment agency to stipulate. However, we encourage the operator to minimise the number of separate applications to minimise the administrative burden on both itself and us.

8.5.3 Before we will agree to release from RSR, operators must meet the following criteria:

- all disposals of radioactive waste have definitively ceased; and
- the site meets our standards (as set out in chapters 4 and 5).

8.5.4 In all cases, the operator will need to demonstrate that the first criterion above is met for the area subject to the application (whether part or all of the site) and that the second criterion will be met for the site as whole. Here "site" has the meaning described in paragraph 8.3.2.

8.5.5 Where an operator seeks release of a part of a site, we will need to be satisfied that further work in the area for which release is sought will not be required in order to meet the standards across the site as a whole.

8.5.6 Operators need to satisfy both criteria before we will agree to their release from RSR and we can refuse the application where the operator is unable to make these demonstrations to our satisfaction.

8.5.7 These criteria are described in turn below.

Definitive cessation of radioactive waste disposal

8.5.8 RSR permits for nuclear sites are issued for the disposal of radioactive waste, and operators thus need to have definitively ceased waste disposal before we will agree to any application for release from RSR. This means in practice:

- operators are no longer carrying on any process or activity on site involving the generation and disposal of radioactive waste and there is no prospect of resuming such activities. This includes all work involving radioactive substances necessary to bring the site to a condition at which it can be released; and
- there is no waste on site awaiting disposal (whether disposals on-site or transfers off-site).

8.5.9 The first point means that, in general, all processes or activities that may generate radioactive waste for disposal, such as operational plant, the processing and treatment of waste, or decommissioning and clean-up, have definitely ceased on the part of the site for which release is sought. That is, they have ceased permanently rather than are being suspended for a period, such as during “care and maintenance”, before being restarted later.

8.5.10 In particular, operators will need to demonstrate that all planned work involving radioactive substances necessary to bring the site to a condition at which it can be released has been completed. That is, the site (or the part of the site subject to the application) has passed the “end of planned work”, shown in Figure 4. Operators should demonstrate the end of planned work through a combination of:

- Completion of all planned works as set out in the WMP; and
- Demonstration through the SWESC that the standards for release will be met without the need for further work involving radioactive substances. This demonstration is linked to “meeting our standards for release” in the next sub-section.

8.5.11 Waste awaiting disposal means radioactive waste that has not yet been disposed of lawfully by transfer from the site, or by on-site burial, deposit or leaving in situ in accordance with the site’s RSR permit. Waste lawfully disposed of on the site remains radioactive waste until the site is released from RSR, at which point it ceases to be radioactive waste. We will not grant release from RSR where waste, including waste in situ, remains on site awaiting disposal.

Meeting our standards for release

8.5.12 The second criterion for release in 8.5.3 is that the operator uses the SWESC to demonstrate to us that the site meets the standards in this guidance for the protection of people and the environment.

8.5.13 The site reference state has been attained when the SWESC shows that the residual risks presented by radioactivity remaining on site are, and will continue to be, consistent with our risk and dose guidance levels (including human intrusion), without the need for controls to limit exposures. This means that the site is available for unrestricted use and the operator may apply for release of the site from RSR.

8.5.14 However, if the SWESC relies on a period of restricted use (see 8.3.11 to 8.3.15) to maintain controls to limit exposures until the residual risks have naturally attenuated to become consistent with our guidance levels, the site reference state will not be attained until the need for those controls has come to an end (see Figure 2). As we explain at 8.3.12, this must occur no later than 300 years after cessation of all planned works on site involving radioactive substances.

8.5.15 The operator may also apply for release of the site from RSR before the end of the period of restricted use. We may agree, if the operator can provide assurance that the arrangements for control of the site, necessary to protect people and the environment, can and will be undertaken and maintained by another suitable body for the duration of the period of restricted use claimed in the SWESC. This corresponds, in Figure 2, to the time of release taking place at a point where substantial controls, needed to protect people and the environment, can give way to reduced controls, which may be managed and regulated by bodies other than the operator and the environment agency. Depending on the particular circumstances of a site this could occur at any point between the times of “earliest release” and “latest release” in Figure 2.

8.5.16 In all cases we anticipate there will be a minimum period before release from RSR to allow for validation monitoring (see Requirement R13).

8.5.17 We will not normally agree to partial release of a site, where this leaves a number of physically separate parts of the original site subject to regulation and potentially with restrictions on use. That is because we consider that such partitioning of the site into separate areas might have an adverse effect on regulation under RSR and on the provision of site surveillance and controls on use, both before and after release from RSR. A site may decrease in extent by progressive release of peripheral areas, but we expect there to be a single and continuous permitted area until full and final release from RSR.

8.5.18 As a general simplifying presumption, any land containing or contaminated by radionuclides below the RSR out-of-scope values may be taken to meet the standard for release from RSR without further assessment of radiological effects. This does not mean there is a general expectation that land should be remediated to out-of-scope values, but rather that where this is the case the standard is presumed to have been met without more detailed assessment. This remains subject to satisfactory characterisation of the area being considered for release from RSR.

Interaction with ONR de-licensing

8.5.19 There is currently no formal statutory link between surrender of the RSR permit and ONR’s process for de-licensing (taken to include ending of the period of responsibility) under NIA 65. Under EPR an operator can apply for surrender at any time. For clarity, this means that there are no legal requirements about the order in which an operator can seek surrender of the permit and de-licensing of the site, nor any statutory interaction between the two.

8.5.20 We do not accept that ending of the period of responsibility under NIA 65 is an automatic or sufficient demonstration that the permit can be surrendered. In every case, the operator needs to apply and make the necessary demonstrations to the relevant environment agency for surrender of its RSR permit.

8.5.21 We would, however, encourage operators to coordinate their plans for RSR release with arrangements for compliance with the specific conditions in its nuclear site licence that affect land quality management. As appropriate, the operator's planning for RSR release should also align with its intent to satisfy ONR requirements.

Part IV Figures

9. Figures

Figure 1 Possible disposition of radioactivity from a decommissioning nuclear site

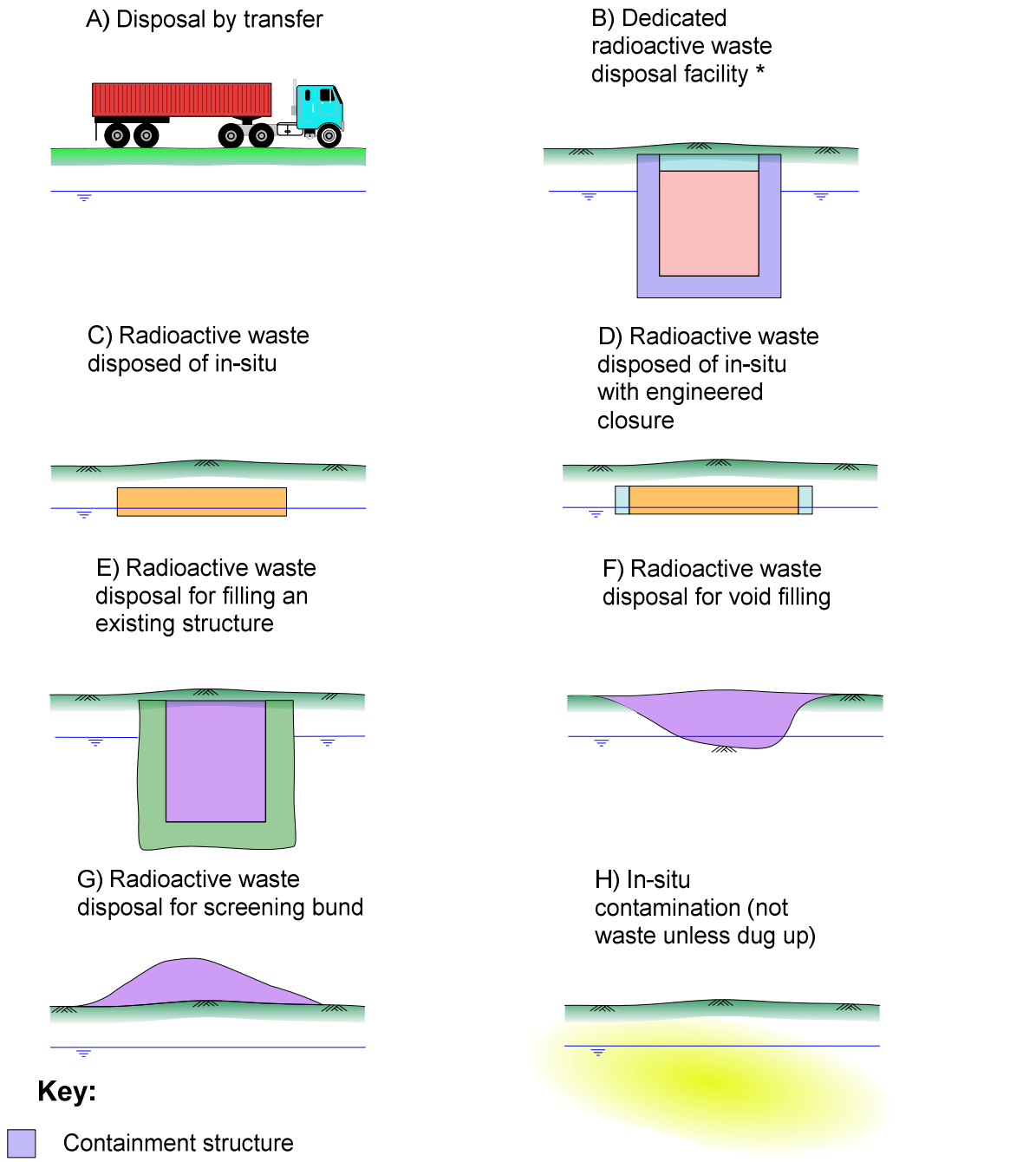


Figure 2 Control of nuclear sites during and after decommissioning

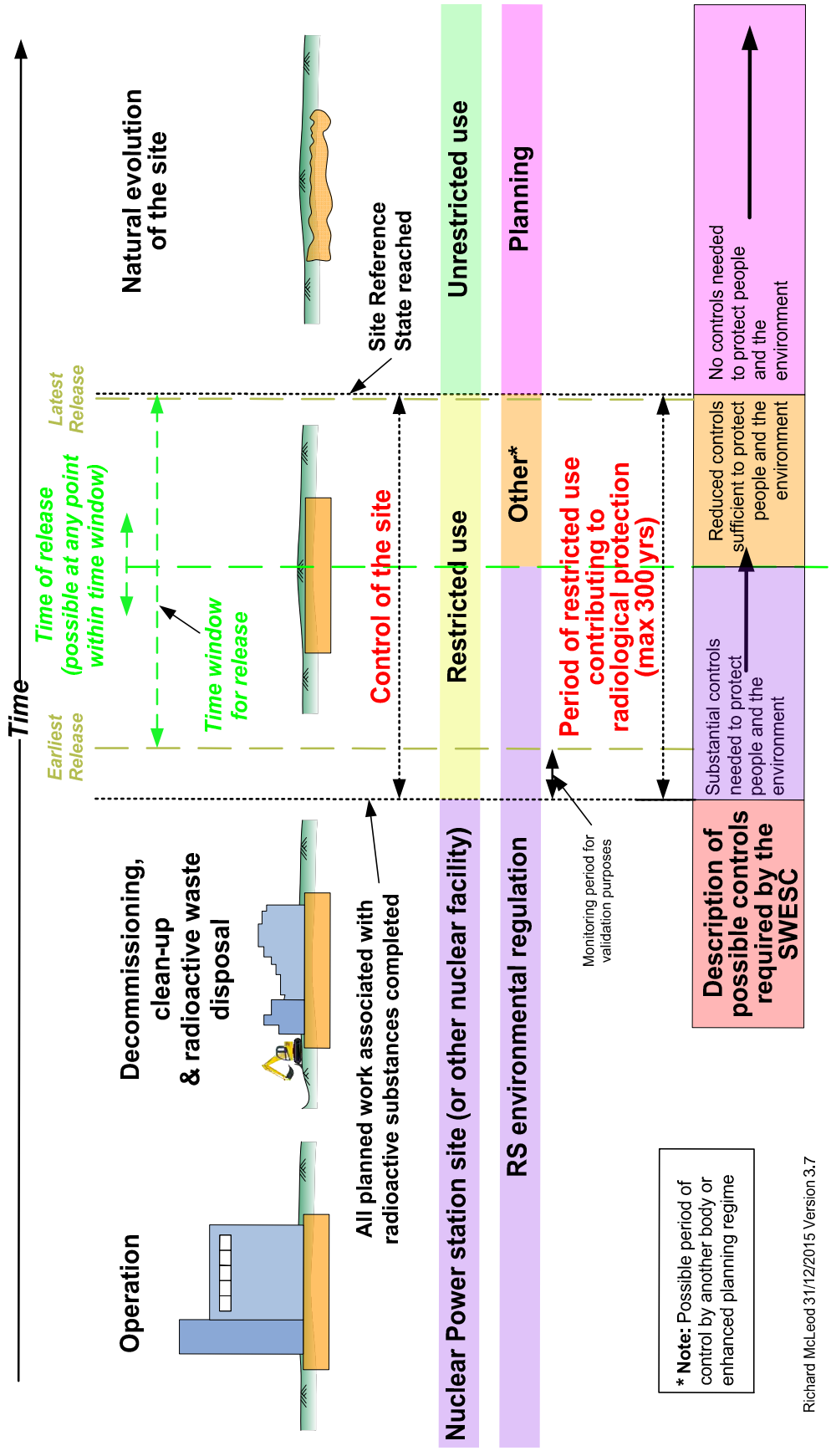


Figure 3 Trade-offs for on-site management of radioactive waste

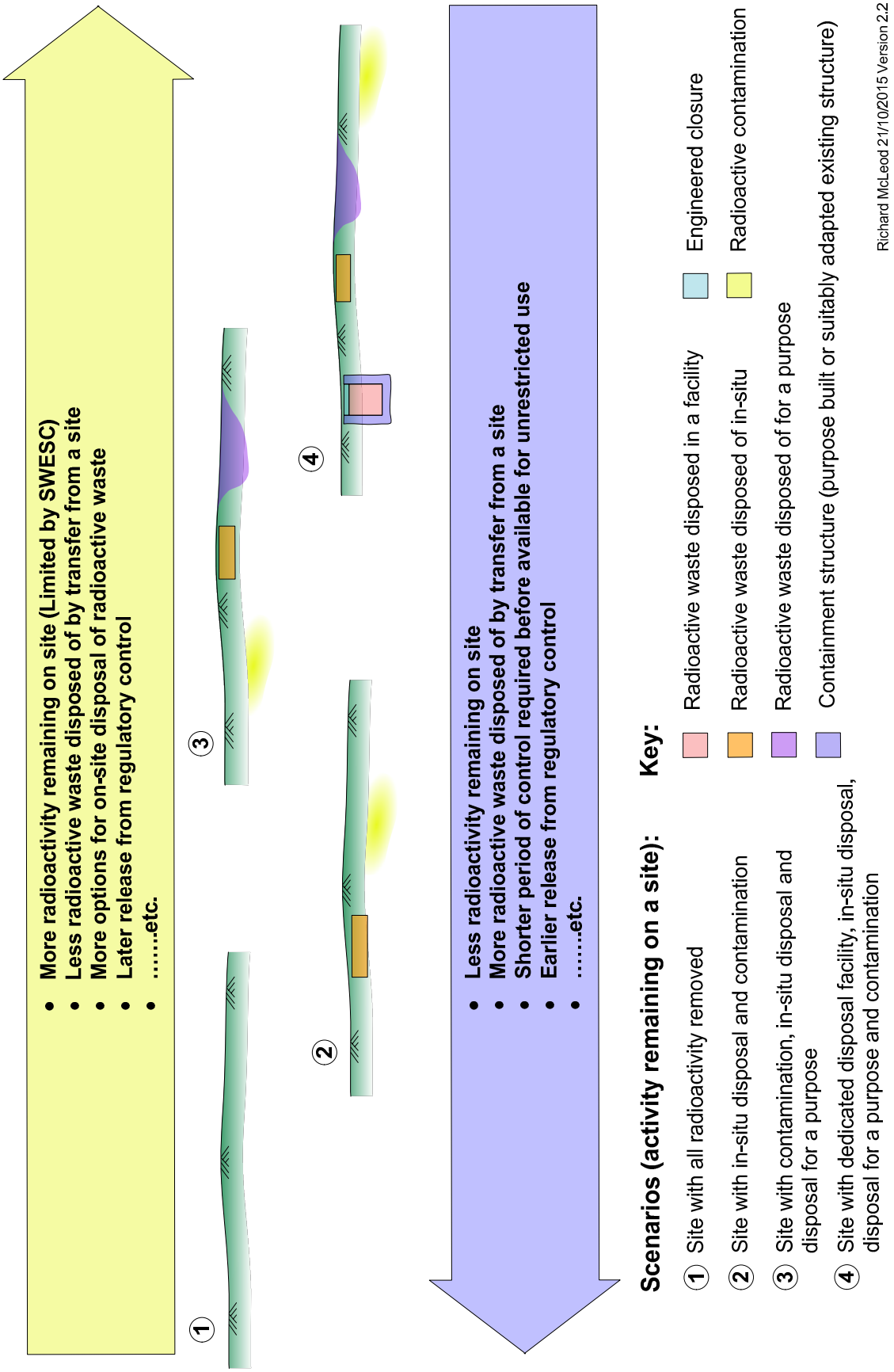


Figure 4 Periods of applicability for the dose constraint and the risk guidance level

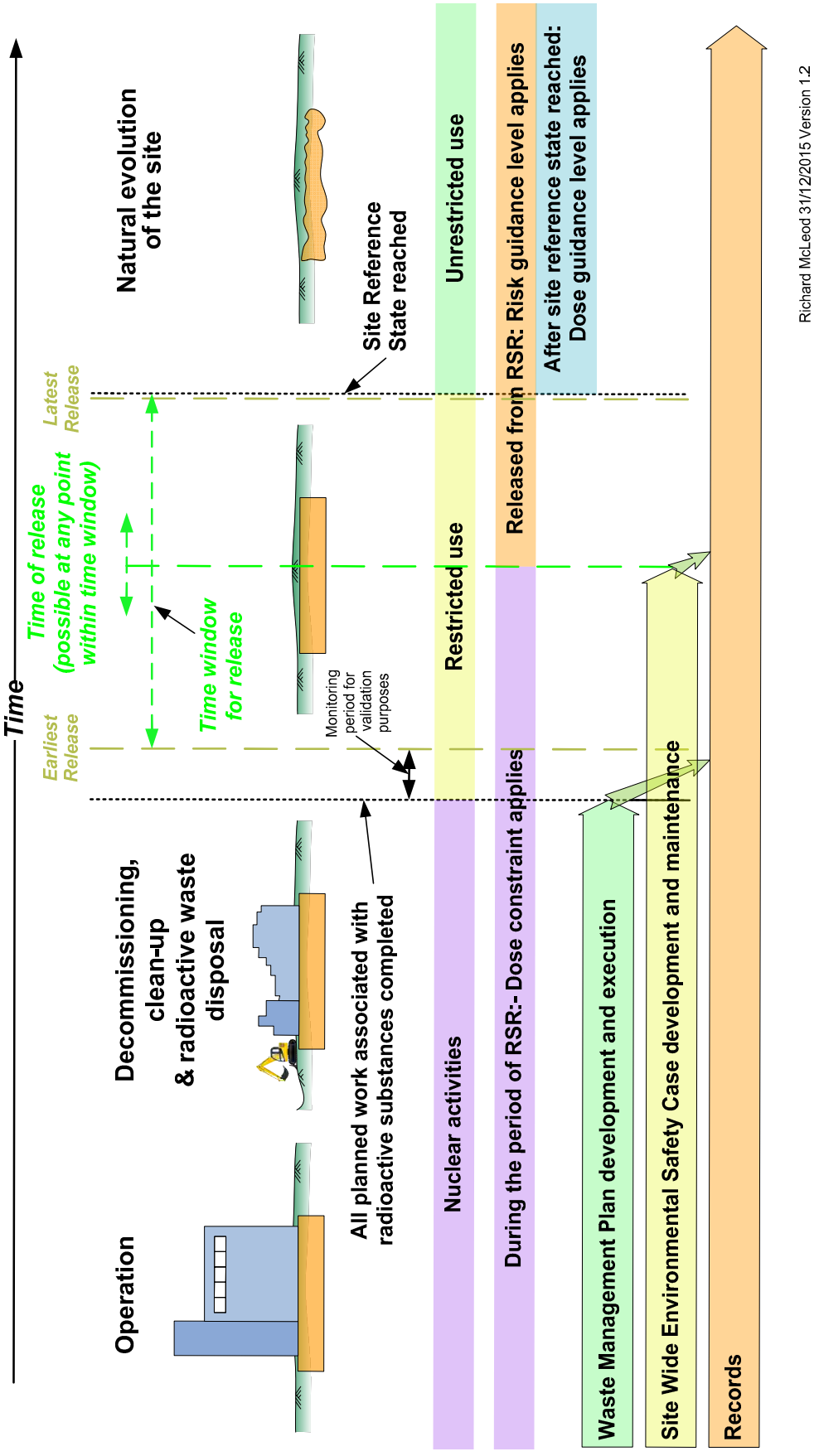


Figure 5 Relationship between SWESC and the NS-GRA

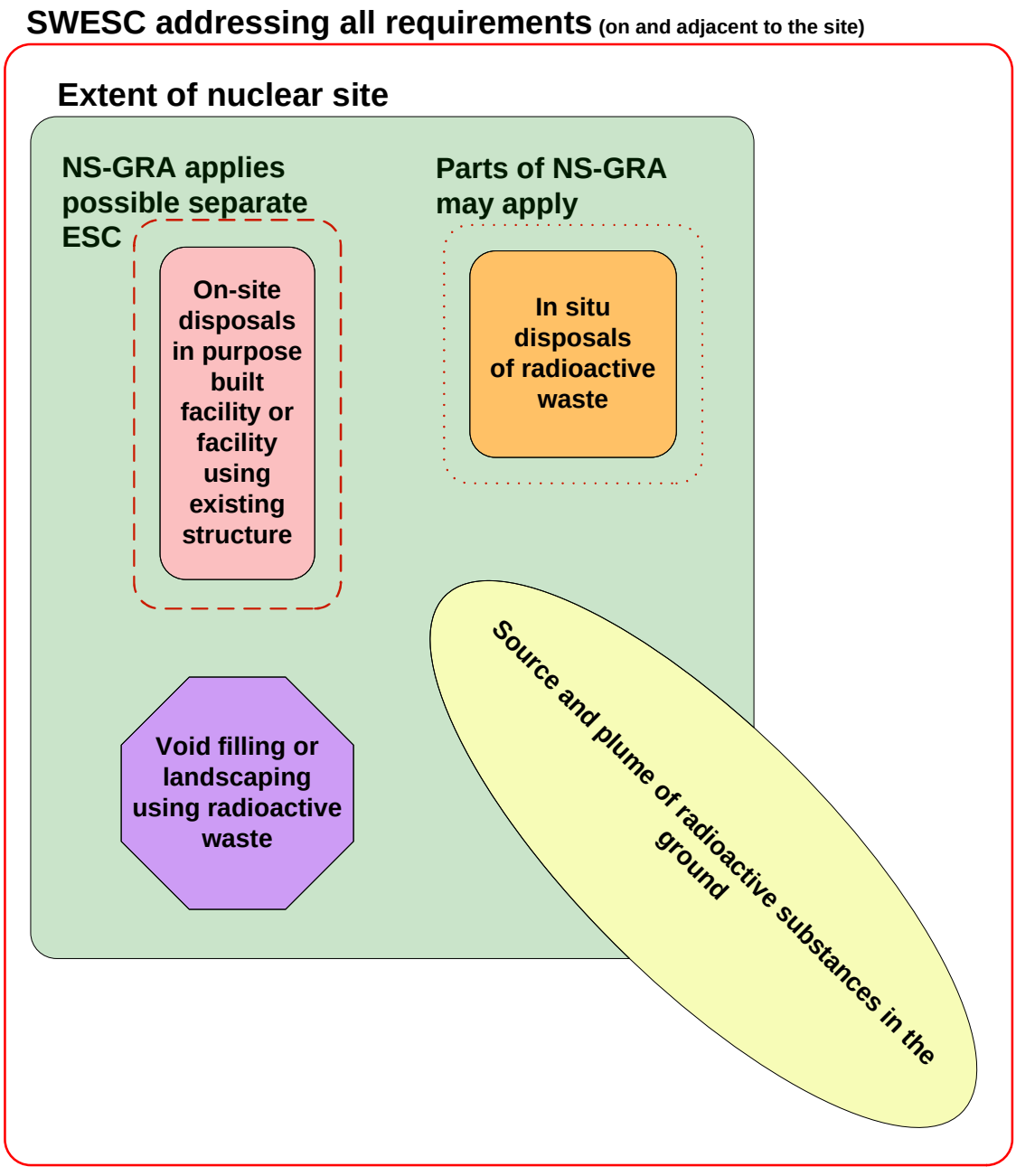


Figure 6 Approach to the treatment of uncertainties

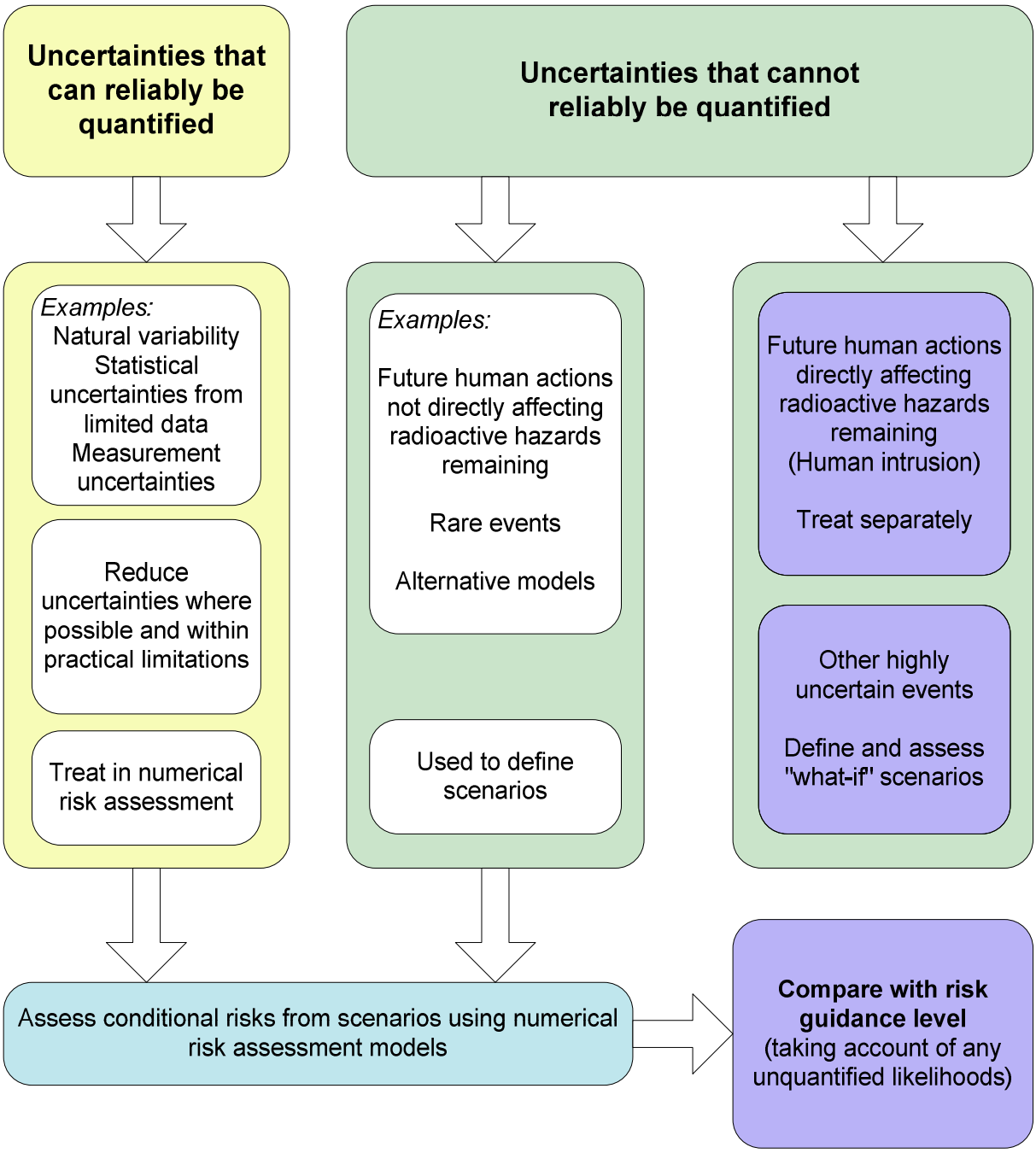


Figure 7 Approach to the treatment of human intrusion after the site reference state has been reached.

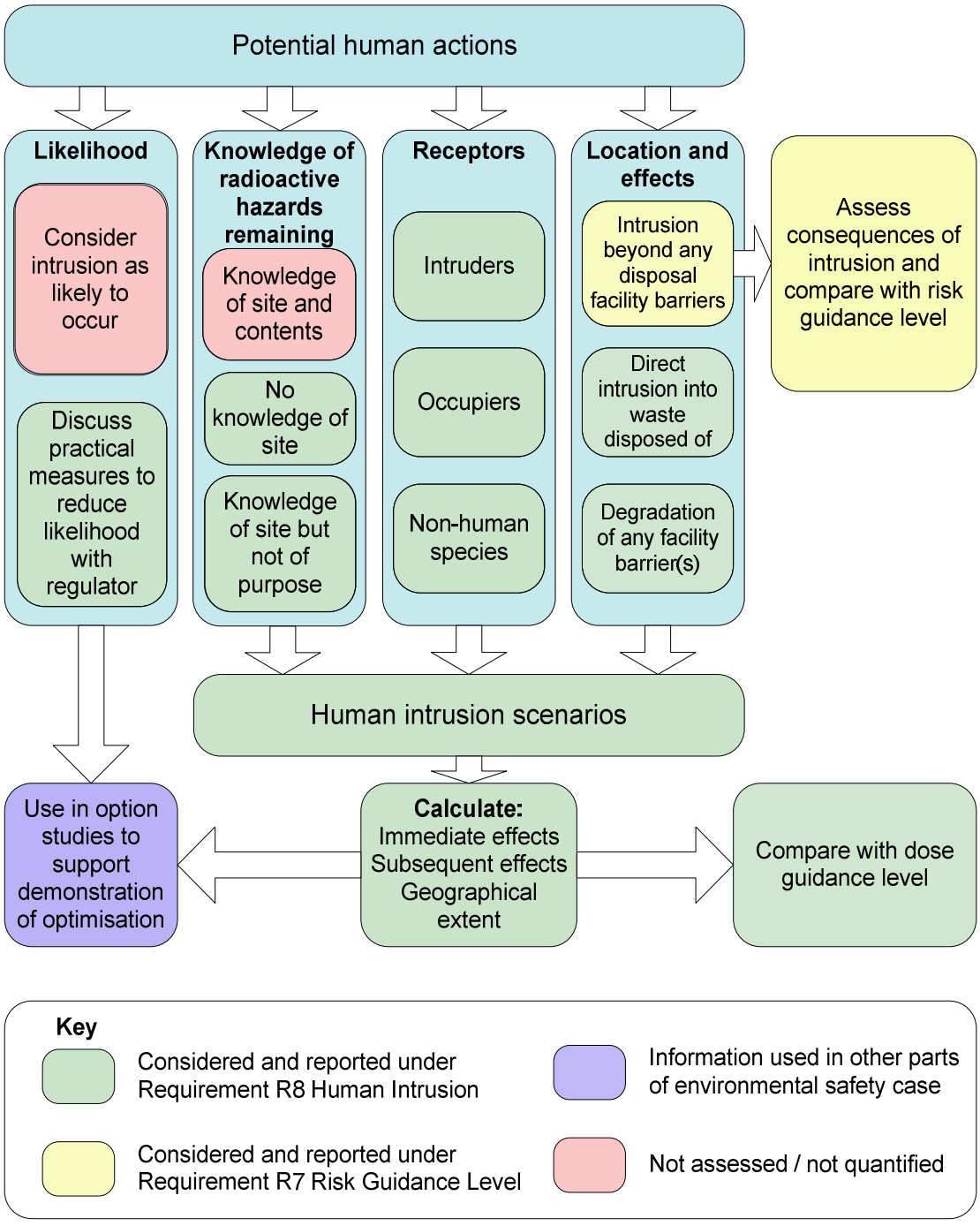
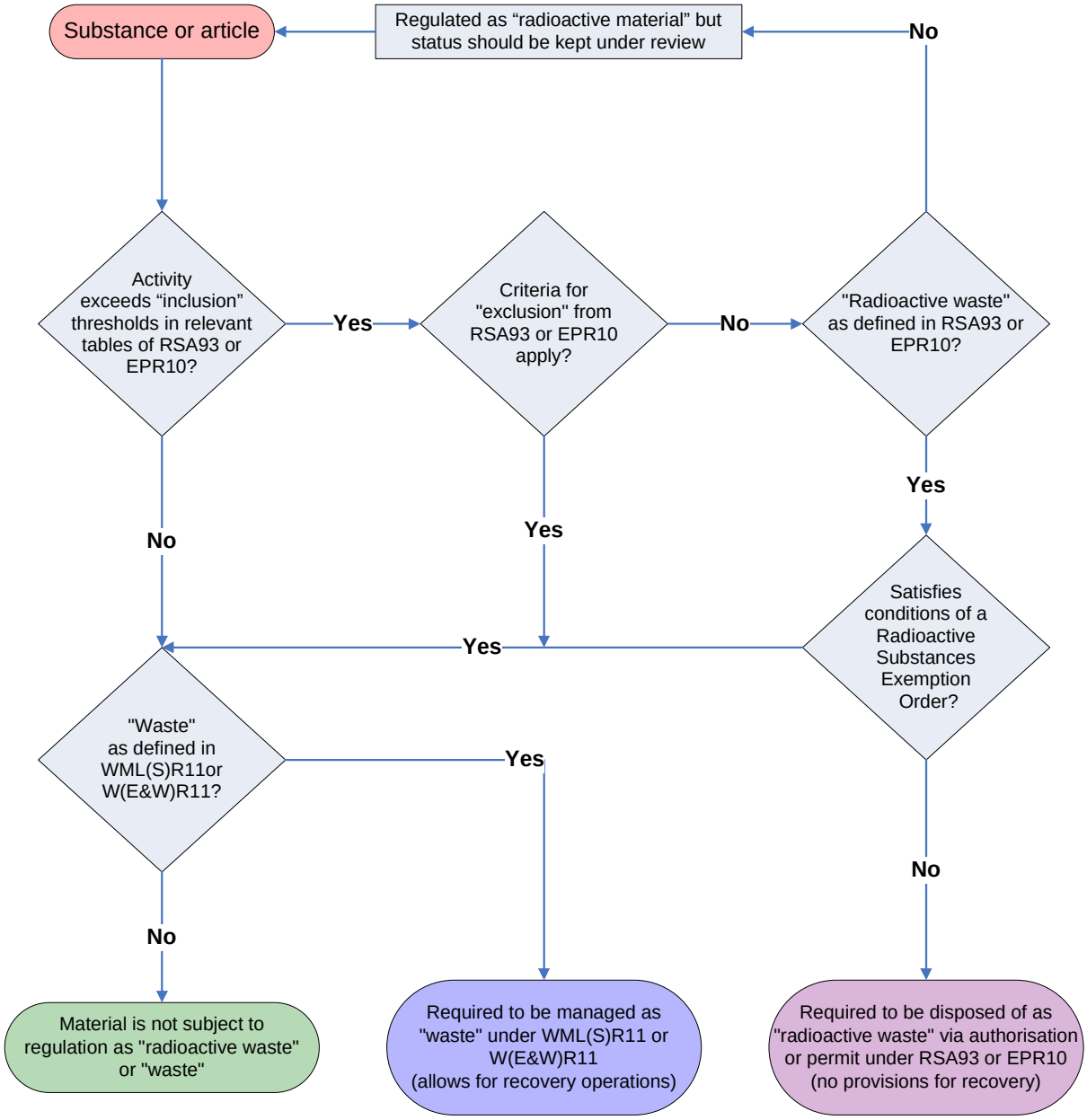


Figure 8 Relationship between "radioactive waste" and "directive waste" management



Key: **RSA93** = Radioactive Substances Act 1993 **EPR10** = Environmental Permitting (England & Wales) Regulations 2010
WML(S)R11 = Waste Management Licensing (Scotland) Regulations 2011 **W(E&W)R11** = Waste (England & Wales) Regulations 2011

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Notes to Figure 8

- Background, both natural and artificial (arising from global circulation of radionuclides from past activities) may (with some restrictions) be deducted prior to comparison with relevant tables in RSA93/EPR10.
- A substance or article containing radionuclides only with half-life <100s is excluded.
- A substance or article contaminated by radioactivity is not radioactive material provided it was not contaminated to use its radioactive, fissile or fertile properties AND it remains on the premises where it was contaminated. This exclusion ceases to apply once the material is removed from the premises, and/or it becomes radioactive waste.
- A substance or article contaminated as a result of lawful disposal of radioactive waste is excluded from RSA93/EPR10 i.e. it is neither radioactive material nor radioactive waste. Solid radioactive waste ceases to be radioactive waste once the authorisation or permit under which it was disposed of has been revoked or surrendered. Any such excluded substances, articles or waste may become radioactive waste again if subsequently subject to a process, unforeseen at the time of disposal, that significantly increases exposures to people or biota.
- Property (i.e. land) contaminated by radioactivity is excluded, provided the contamination remains in situ. If remediation of the property produces waste which falls within scope of RSA93/EPR10, then that is radioactive waste, and must be disposed of in accordance with a permit or an exemption order.

NB. These notes are intended only as a summary; for full understanding of the law, please consult the relevant legislation and the Government-published Guidance on the scope of and exemptions from the radioactive substances legislation in the UK(PB 13624)September 2011.

NOTE:

On a nuclear licensed site, radioactive material, radioactive waste and radioactively contaminated land and groundwater are regulated by the Office for Nuclear Regulation as "nuclear matter" under the conditions of the nuclear site licence.

Part V:
References, Glossary and Acronyms

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11. Glossary and Acronyms

11.1 Glossary of terms

For terms not listed below, refer to:

1. IAEA Safety Glossary at: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1290_web.pdf;

2. Documents available on the Health Protection Agency website, especially the Glossary at: http://www.hpa.org.uk/radiation/glossary/default.htm;

3. General technical dictionary.

Definitions

Accessible environment
Those parts of the environment in contact with or readily available for use by humans.

Assessed radiological risk
See *Radiological risk.*

Biosphere
That part of the environment normally inhabited by living organisms. In practice, the biosphere is generally taken to include the atmosphere and the Earth's surface, including the soil and surface water bodies, seas and oceans and their sediments. There is no generally accepted definition of the depth below the surface at which soil or sediment ceases to be part of the biosphere, but this might typically be taken to be the depth affected by basic human actions, in particular farming.

Closure
Technical and administrative actions to put a *Disposal facility* in its intended final state after the completion of waste *Emplacement*.

Collective radiological impact
An indicator of the total radiological consequences from a particular source of exposure on a defined population over some period of time. It might be expressed as an assessed collective dose together with the assessed probability of that collective dose arising.

Conceptual model
A set of qualitative assumptions used to describe a system, or part of a system, in the real world.

Conservative (of assumptions and data)
Selection of cautious assumptions, or worst case data values, for the purposes of modelling.

Deterministic assumption
Fixed assumption, taken to have a probability of 1, made for the purpose of exploring, developing, or establishing the *Environmental safety case*.

Disposal
Disposal is the *Emplacement* of waste without intent to retrieve it at a later time; retrieval may be possible but, if intended, the appropriate term is storage. We shall regard the time of emplacement as the time of disposal.

Disposal (in situ)
An application for authorisation to dispose of the waste based on a decision not to retrieve it.

Disposal facility (for solid radioactive waste)
An engineered facility for the *Disposal* of solid radioactive wastes.

Dose guidance level (for human intrusion)
The dose standard against which the radiological consequences of *Human intrusion* are assessed. It indicates the standard of *Environmental safety* expected but does not suggest that there is an absolute requirement for this level to be met.

Environmental safety
The safety of people and the environment both during the period of RSR and afterwards into the indefinite future.

Environmental safety case
The collection of arguments, provided by the developer or operator of a disposal facility, that seeks to demonstrate that the required standard of *Environmental safety* is achieved.

Environmental safety culture
The characteristics and attitudes of organisations and individuals that ensure that the protection of people and the environment receives proper attention.

Environmental safety functions
The various ways in which components of the *Disposal system* may contribute towards *Environmental safety*, e.g. the host rock may provide a physical barrier function and may also have chemical properties that help to retard the migration of radionuclides.

Environmental safety strategy
An approach or course of action designed to achieve and demonstrate *Environmental safety*.

Expert judgement
Expert judgement is an approach for obtaining and using informed opinions from individuals with particular expertise. Such judgement may be required when the data available require expert interpretation. Structured expert judgement, or expert elicitation, refers to the application of transparent methodological rules to the judgement process.

Exposed group
For a given source, any group of people within which the exposure to radiation is reasonably homogeneous; where the exposure is not certain to occur, the term ‘potentially exposed group’ is used.

Hazard
A property or situation that in certain circumstances could lead to harm.

Host rock
The geological medium in which a disposal facility is located.

Human intrusion
Any human action that accesses the waste or that damages a barrier providing an *Environmental safety function* after the release from RSR.

Low level waste (LLW)
In Government policy, low level waste is defined as 'radioactive waste having a radioactive content not exceeding four gigabecquerels per tonne (GBq/te) of alpha or 12 GBq/te of beta/gamma activity'. It consists largely of paper, plastics and scrap metal items that have been used in the nuclear industry, hospitals and research establishments. In future, there will also be large volumes of LLW in the form of soil, concrete and steel, as existing nuclear facilities are decommissioned.

Model
A representation or description of a system (or part of a system) in the real world, designed to show or explore how the system would behave under specified conditions.

Monitoring
Taking measurements so as to be aware of the state of the site and any changes to that state. Monitoring may include measuring levels of radioactivity in samples taken from the site or from the environment, and also measuring geological, physical and chemical parameters relevant to environmental safety.

Near-surface disposal facilities
Facilities located at the surface of the ground or at depths down to several tens of metres below the surface. Near-surface facilities may use the geology (rock structure) to provide an *environmental safety function*, but some may rely solely on engineered barriers.

Nuclear site (definition from RSA 93 or EPR 2010)
(a) any site in respect of which a nuclear site licence is for the time being in force, or
(b) any site in respect of which, after the revocation or surrender of a nuclear site licence, the period of responsibility of the licensee has not yet come to an end,

The authorised premises may not always be identical to the nuclear licensed site. In our use of the term "nuclear site" in this document we are referring to the area of land that is subject to our legislation as indicated by the plan in the permit.

Optimisation
Optimisation is the principle of ensuring that radiation exposures are as low as reasonably achievable (ALARA) in the given circumstances. Optimisation is an important principle of radiation protection recommended by the International Commission on Radiological Protection (ICRP) and incorporated into UK legislation.

Peer review
A formally documented examination of a technical programme or specific aspect of work by a suitably qualified expert or group of experts who have not been involved in the programme or aspect of work.

Period of restricted use
A period of time during which controls over a site provide a contribution to radiological protection of people and the environment.

Potential exposure (to ionising radiation)
Exposure to ionising radiation that is not certain to occur.

Potentially exposed group
See *Exposed group.*

Probability distribution (of dose)
A distribution of exposures to ionising radiation that expresses the probability that a given exposure or range of exposures will occur.

Quantifiable Uncertainties
Uncertainties associated with a parameter for which numerical estimates of possible values can be made. Uncertainties are quantifiable when there are observations, experiments or models available that can give rise to distributions of values. *Expert judgement* may be needed to interpret such distributions in order to estimate a numerical value for the uncertainty associated with a particular use of the parameter.

Radiological risk
The probability per unit time that an individual will suffer a serious radiation-induced health effect as a result of the presence of a radiation source, for example, a disposal facility. In this context, a serious radiation-induced health effect is a fatal cancer or a severe hereditary defect. Radiological risk can only be assessed and not measured.

Risk
A combination of the probability that someone or something valued will be adversely affected by a *Hazard* and the magnitude of the consequences that might arise from that hazard.

Risk assessment
An assessment of *Radiological risk*.

Risk guidance level
A level of *Radiological risk* from a nuclear site which provides a numerical standard for assessing the *Environmental safety* of the site after the release from RSR.

Scenario
A postulated or assumed set of conditions and/or events.

Site
For a disposal facility, the piece of land where the facility is, or is intended to be, located. More generally, the piece of land where one or a number of sources of radioactivity are, or are intended to be, located.

For decommissioning sites, the piece of land that is delineated by the permit as constituting the authorised premises.

Site characterisation
Surface and sub-surface investigations to determine the suitability of a site for a disposal facility for solid radioactive waste and to gather information about the site to support an *Environmental safety case*.

Site constraint
The site-related dose constraint applies to the aggregate exposure resulting from discharges from a number of sources with contiguous boundaries at a single location. It includes the radiological effects of current discharges from the entire site, but excludes the effects of direct radiation and historical discharges. The site constraint of 0.5 mSv/year applies irrespective of whether different sources on the site are owned and operated by the same or by different organisations.

Site reference state (of a nuclear site):
Site state marking the boundary between the period of restricted use of a site and a subsequent period of unrestricted use.

Site-wide environmental safety case (for a nuclear site)
A set of claims, prepared by the site operator, concerning the environmental safety of the nuclear site taken as a whole. The site-wide environmental safety case (SWESC) addresses the present state and all envisaged future states of the site, both during the lifetime of the permit and during the indefinite period after the permit has been surrendered. The SWESC considers all the anthropogenic radioactivity remaining on or adjacent to the site, seeking to demonstrate that, with respect to the radiological hazard and any non-radiological hazards associated with this radioactivity, people and the environment will be protected. For the period after the permit has been surrendered, the SWESC considers evolution of the site without operator control. The SWESC is closely linked to the waste management plan (WMP) and should maintain consistency with it.

Stakeholder
People or organisations, having a particular knowledge of, interest in, or be affected by, radioactive waste, examples being the waste producers and owners, waste regulators, non-Governmental organisations concerned with radioactive waste and local communities and authorities.

Storage (of waste)
Placing waste in a suitable facility with the intent to retrieve it at a later date.

Stylised approach (to demonstrating environmental safety)
An approach to constructing part of an *Environmental safety case* (e.g. modelling the biosphere), through making arbitrary assumptions that are either generally reasonable or clearly *Conservative*. Can be used in the absence of specific information.

Surveillance (of a nuclear site)
Close observation of specified aspects of the site, either by the site operator during the lifetime of the permit, or through other organisational arrangements subsequently. After the end of all planned work on site involving radioactive substances, surveillance is needed during any period of restricted use to ensure that the state of the site remains consistent with the assumptions of the SWESC. Surveillance determines whether any physical actions not previously planned, or interventions to prevent actions by others, may be needed to restore or maintain consistency with the SWESC. It hence implies the ability to initiate such actions or

interventions if they should be needed. Surveillance may include validation monitoring, during any period while this form of monitoring is being undertaken.

Uncertainty
Lack of certainty. A state of limited knowledge that precludes an exact or complete description of past, present or future.

Unquantifiable Uncertainties
Uncertainties for which no numerical estimates can reliably be made. Uncertainties are unquantifiable when there are no observations, experiments or models available that can be used to provide numerical estimates. The effect of these uncertainties may be explored by making alternative sets of conjectural assumptions and determining how these affect the outcome of an analysis.

Unrestricted use
Possible uses of a site after release of a site from RSR that are reasonable based on current human behaviours but not including fanciful uses.

Validation monitoring
Monitoring to confirm that the state and behaviour of the site is in accordance with the assumptions of the SWESC. Validation monitoring is carried out by the permit holder and may continue for a period after the end of all planned work on site involving radioactive substances.

Waste acceptance criteria
Quantitative and/or qualitative criteria, specified by the operator of a *Disposal facility* and approved by the regulator, for solid radioactive waste to be accepted for disposal.

Waste management plan (for a nuclear site)
A plan, prepared by the site operator, for the nuclear site as a whole, which provides a comprehensive description of the current intent for dealing with all the anthropogenic radioactivity remaining on or adjacent to the site. The waste management plan (WMP) may be regarded as part of the wider decommissioning and clean-up plan for the site. It covers all actual and prospective forms of radioactive waste, including existing waste, waste anticipated to arise and waste in situ. It identifies all current and prospective forms of radioactive waste disposal on or off site, including disposal by emplacement on site (e.g. into an on-site waste disposal facility or for void filling), disposal by leaving waste in situ and disposal by transfer off site. It takes into account both radiological and non-radiological hazards, and is based on an integrated approach to the management of all wastes, both directive and radioactive wastes, over the lifetime of the facility. The WMP is closely linked to the site wide environmental safety case (SWESC) and should maintain consistency with it.

'What-if' scenario
A *Scenario* put forward to explore the consequences of a defined set of assumptions.

11.2 Acronyms

ALARA	As low as reasonably achievable
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EC	European Commission
EPR 2010	Environmental Permitting Regulations 2010
EURATOM	European Atomic Energy Community
NICoP	Nuclear Industry Code of Practice
NRW	Natural Resources Wales
NS-GRA	Near-Surface Guidance on Requirements for Authorisation
HPA	Health Protection Agency (now Public Health England)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
LLW	Low-level radioactive waste
PHE	Public Health England (formally Health Protection Agency)
NIA 65	Nuclear Installations Act 1965
RSA 93	Radioactive Substances Act 1993
RSR	Radioactive Substances Regulation
SEPA	Scottish Environment Protection Agency
SWESC	Site Wide Environmental Safety Case
WMP	Waste Management Plan