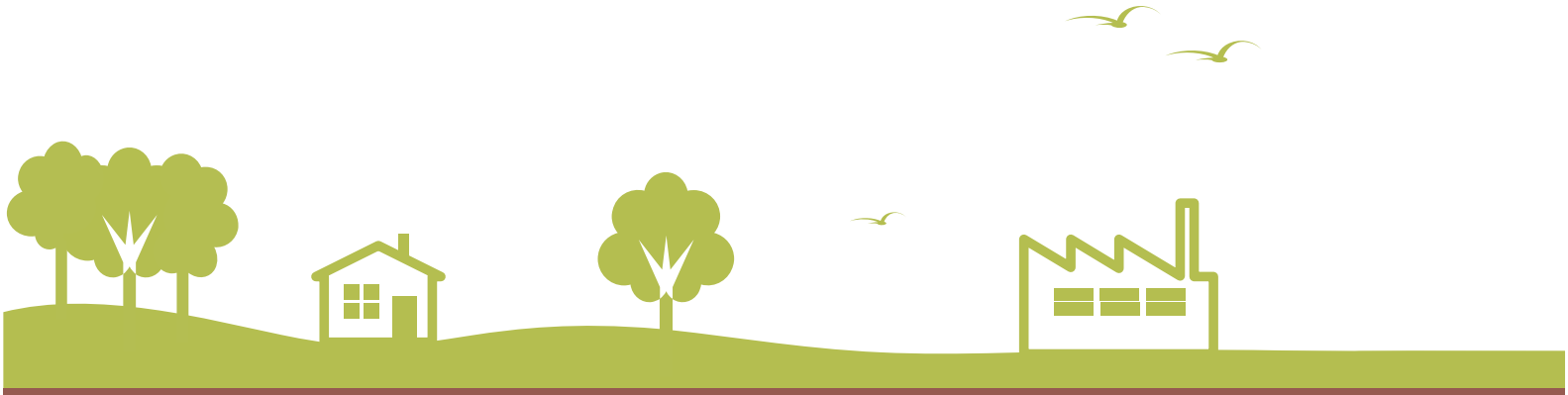

Management of radioactive waste from decommissioning of nuclear sites: Guidance on Requirements for Release from Radioactive Substances Regulation

Version 1.0: July 2018

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Foreword

At nuclear sites, decommissioning means the dismantling of facilities and structures that have reached the end of their useful lives. Clean-up means treating or removing contamination from leaks or spills on or around the site. The final stages of decommissioning and clean-up will involve managing large amounts of radioactive waste, as well as other conventional waste.

Waste with higher levels of radioactivity will need to be moved into secure stores, where it will be kept safely under supervision, until dedicated disposal facilities can be constructed. Most nuclear sites already have well established programmes for this.

Most of the waste from decommissioning and clean-up will have only relatively low levels of radioactivity. Much of this waste will be made up of things like demolition rubble, scrap metal, foundations, drains and pipelines, or soil. All of this waste will need to be managed safely, and disposed of somewhere suitable. This might be on the site that produced the waste, or after transport to another site.

The Environment Agency, Natural Resources Wales, and the Scottish Environment Protection Agency have a duty to protect members of the public and the environment from harm from radioactive substances. As part of this duty, we regulate the disposal of radioactive waste from nuclear sites.

Together, we have produced this guidance for operators of all nuclear sites. It applies to all sites, whether or not they have already begun decommissioning and clean-up. It also needs to be taken into account when new sites are being designed or constructed.

Our guidance describes what operators need to do, when they are planning and carrying out their work to decommission and clean-up their sites. Our goal is to ensure that operators do this in ways that are safe for people and the environment. This includes both the ways in which they manage their radioactive waste, and the condition in which they leave their sites. This will enable us to release their sites from radioactive substances regulation.

To achieve this, our guidance requires operators to:

- produce a waste management plan
- produce a site-wide environmental safety case
- make sure the condition of their site meets our standards for protection of people and the environment, now and into the future

This guidance describes what operators must do in order to achieve release from radioactive substances regulation.

Our guidance focuses on radioactive substances. We do, however, encourage operators to take a joined-up approach to meeting their obligations under other environmental laws (for example, regulations for the management of non-radioactive waste).

We encourage operators to discuss their proposals for decommissioning and clean-up with us at an early stage, before they make any formal applications. We also expect them to engage early and widely with local communities and the general public, and with their other regulators (for example, for nuclear safety and security, or for land-use planning).

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1. This Guidance

1.1 Introduction

1.1.1 This guidance is for operators of nuclear sites that hold, or intend to hold, an environmental permit for the disposal of radioactive waste.

1.1.2 In this guidance we describe what operators of nuclear sites need to do, over the lifetime of their site, so that the site can be released from radioactive substances regulation (RSR) when all activities involving the management of radioactive waste have ceased.

1.1.3 This guidance is applicable to all nuclear sites throughout Great Britain.

1.2 Aims of this guidance

1.2.1 This guidance sets out:

(i) the requirement for optimised plans for the management of the radioactive wastes from decommissioning and clean-up of a nuclear site
(ii) the standards that must be met if those optimised plans identify that radioactive wastes are best managed by on-site disposal
(iii) the standards that a nuclear site must meet to enable it to be released from RSR

1.3 Our standards and requirements

1.3.1 Our fundamental protection objective is to ensure that a nuclear site is brought to a condition at which it can be released from RSR, 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.

1.3.2 The environment agencies will only agree to release a nuclear site from RSR if we are satisfied that radioactive waste disposal has ended and that the site is in a state, the reference state, that will ensure people and the environment are protected.

1.3.3 We require nuclear site operators to establish and maintain a suitable Waste Management Plan (WMP) and a Site-Wide Environmental Safety Case (SWESC) as the means by which they should demonstrate that their site meets the standards for proper protection of people and the environment.

1.3.4 In this guidance we express our standards through five Principles and fifteen specific Requirements. The principles and requirements are set out in Annex A.

1.4 About the environment agencies and this guidance

1.4.1 The Environment Agency (EA), Natural Resources Wales (NRW), and the Scottish Environment Protection Agency (SEPA) (the environment agencies) are the environmental regulators for England, Wales and Scotland, respectively. This guidance is a joint publication by the three environment agencies. For simplicity, we have used the terms ‘the environment agencies’, ‘we’, ‘us’, or ‘our’ throughout this guidance when we refer to these organisations collectively.

1.4.2 Our responsibilities with respect to radioactive substances include regulating the disposal of radioactive waste on or from nuclear sites, so that members of the public and the environment are protected. All disposals of radioactive waste must be authorised and operators must comply with conditions and limits set out in permits granted by the relevant environment agency.

1.4.3 Our main audience is a specialist one. This guidance sets out our requirements clearly and unambiguously and therefore contains many specialist terms that have precise meanings. To make the guidance easier to understand we have included a glossary of specialist terms.

1.4.4 In preparing this guidance and when undertaking our duties to protect people and the environment, in particular we are required to work in a way that is transparent, proportionate and consistent, in accordance with the Legislative and Regulatory Reform Act 2006, the Regulators' Code (BIS, 2014) in England and Wales, and with the Scottish Regulators' Strategic Code of Practice (Scottish Government, 2015) in Scotland.

1.5 Relevant policy and legislation

1.5.1 When reading and applying this guidance it should be interpreted in a wider context including, but not limited to:

- all relevant environmental legislation
- relevant government policy
- statutory guidance published by government
- other guidance issued under the RSR regime
- relevant guidance on regulation of non-radioactive substances and protection of the environment

1.5.2 The environment agencies deliver government policy through the implementation of relevant legislation. Therefore, this guidance has been prepared with due regard to the 2004 statement of the UK government and devolved administrations' policy on Decommissioning of the UK Nuclear Industry's Facilities, as well as the Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom (Defra, 2007). In particular the Low Level Waste policy includes expectations that radioactive waste is not created where practicable, plans for the management of LLW are prepared based on an assessment of all practicable options, and the proximity principle and transport implications are considered.

1.5.3 The environment agencies regulate radioactive substances on nuclear sites under the Radioactive Substances Act 1993 (RSA 93) [1] in Scotland, and the Environmental Permitting (England and Wales) Regulations 2016 (EPR 2016) in England and Wales. This regulatory regime is referred to in this guidance as 'radioactive substances regulation' (RSR).

1.5.4 Different terminology is used in RSA 93 and EPR 2016. For example, a document defining the conditions and limitations that operators must comply with is termed an 'authorisation' under RSA 93 and a 'permit' under EPR 2016. 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

[1] In Scotland, RSA93 is soon to be repealed and replaced by the Environmental Authorisation (Scotland) Regulations 2018 (EA(S)R 2018). Readers should check which legislation is in force, and interpret references to RSA93 accordingly.

limitations that operators must comply with. Similarly, under RSA 93 an authorisation may be 'revoked', while under EPR 2016 a permit may be 'revoked' or 'surrendered'. This guidance uses the phrase 'release from radioactive substances regulation' to describe the act of revoking an authorisation or surrendering a permit.

1.5.5 We regulate other environmental regimes on nuclear sites, for example non-radioactive (directive) waste and the protection of groundwater.

1.5.6 The Office for Nuclear Regulation (ONR) also regulates nuclear sites for the purposes of ensuring nuclear safety. Section 5 provides further discussion of the interface between RSR and other regulatory regimes.

1.6 Preparing nuclear sites for release from regulation throughout their lifecycle

1.6.1 The lifecycle of a nuclear site extends from its design and construction through operation to decommissioning and final clean-up of the site. Activities involving the production and disposal of radioactive wastes are regulated throughout this lifecycle to ensure not only that the operator can safely manage its disposals of radioactive wastes, but also to ensure that when regulation eventually ceases, the condition of the site is such that members of the public and the environment are properly protected. While the environment agencies have published a number of guidance documents that explain and support our regulation of radioactive waste management on nuclear sites, none of these address the actions and demonstrations that are required to bring a nuclear site to a condition where it can be released from regulation. This guidance is intended to fill that gap.

1.6.2 The journey to release from RSR requires that choices are made about the optimum way of dealing with the radioactivity that remains on a nuclear site after operations have ceased. Such choices include consideration of whether radioactive wastes could and should be disposed of on-site. Similarly, whether contamination could and should be removed from the site. A holistic approach is required that takes account of all sources of radiological (and non-radiological) impact on people and the local environment. This leads to the standards and requirements specified in this guidance having a fundamental dual purpose:

- the assessment and demonstration that the site has been brought to a satisfactory state (the reference state); and
- the assessment and demonstration of the suitability of any proposals for on-site disposal of radioactive waste.

1.6.3 The WMP and SWESC each provide the means by which the operator of a nuclear site should demonstrate compliance with our requirements both during and after radioactive substances regulation of the site. The WMP and SWESC also contribute to meeting the joint regulatory expectations for land quality management at nuclear sites (ONR, NRW, SEPA & EA, 2014).

1.6.4 This guidance describes how the WMP and the SWESC should be developed and used throughout the lifecycle of a nuclear site. We focus on how these tools should be used to optimise the management of wastes arising from decommissioning and clean-up and how they demonstrate that a site has achieved its site reference state (see glossary and 2.2.10 to 2.2.22) so it can be released from RSR.

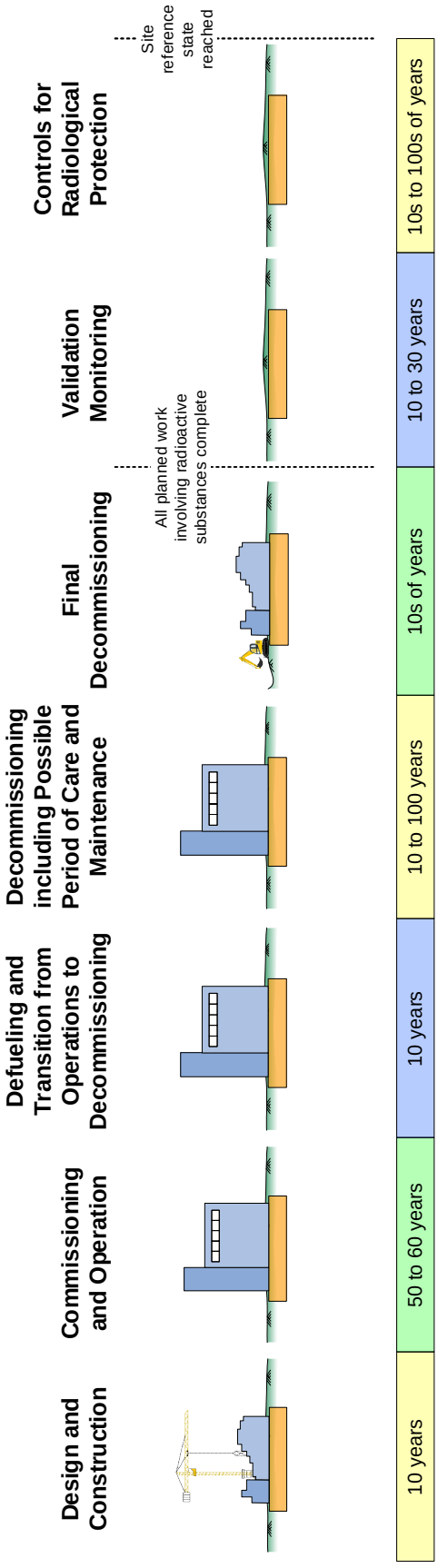
1.6.5 During the life cycle of a nuclear site, the emphasis given to different aspects of the WMP and SWESC will vary. For example, during design and construction a nuclear

site operator might focus development of its SWESC on establishing the characteristics of the site and its surroundings (e.g. its geological setting and the location of sensitive receptors). During operations, the SWESC provides a basis against which operators should consider their response to spills or contamination events. For sites undergoing decommissioning and clean-up the SWESC is key to providing a demonstrable case that our requirements for release from regulation will be met.

1.6.6 The same is true of the WMP. During much of the lifetime of the site the WMP will focus on the management of operational wastes. However it will also anticipate the wastes that are expected to arise during decommissioning and clean-up, demonstrating that the plans for the management of these are optimised. Whilst the management of operational wastes is well established and employs a range of existing tools, as more sites embark on decommissioning and clean-up our experience is that it is less clear to operators what choice of options exist for the management of the decommissioning and clean-up wastes. For example, at many sites past operations mean decommissioning may result not only in large quantities of radioactive waste that will need to be managed but also waste in a whole variety of forms which are quite different from operational wastes. The radioactive waste may, if sufficiently contaminated, include demolition rubble, foundations, drains and pipes. Consideration also needs to be given to the management of areas of undisturbed ground or groundwater which may have been contaminated by radioactive substances and which may give rise to radioactive waste.

1.6.7 Figure 1 shows a typical timeline for a nuclear site and shows how operation of the site tends to be followed by decommissioning activities that may take several decades. Decommissioning may include a period of ‘care and maintenance’ during which a site is left in a quiescent state for a period of time prior to final demolition and dismantling of the site structures. After all planned work involving radioactive substances is complete, it may still be many decades before the site can be released from RSR. During this period further controls may need to be exercised on the site to ensure radiological protection of people and the environment, until the site reference state is reached.

Figure 1: Typical timeline for a nuclear site



1.7 The meaning of ‘site’ in this guidance

1.7.1 In general, ‘site’ in this guidance means the area of land delineated on the site plan in the environmental permit as constituting the authorised premises. This is the area within which the radioactive substances activity is carried out and is therefore the area which will eventually be subject to an application for release from RSR.

1.7.2 The geographical extent of the authorised premises may be different from that covered by the nuclear site licence, for example sea pipelines may extend outside the boundary of the nuclear licensed site.

1.7.3 In cases where contamination of ground or groundwater arising from the radioactive substances activity extends beyond the boundary of the authorised premises, such areas should be considered in the scope of the SWESC. This ensures that all potential sources of exposure to people and impacts on the environment are considered. Any radioactive wastes produced by clean-up of these areas should be addressed in the WMP alongside radioactive wastes arising within the site.

1.7.4 Where there are several environmental permits held in the same area, for example in the case of ‘A’ and ‘B’ nuclear power station sites, the SWESC prepared for each permit should include any potential combined impacts on any representative persons (see glossary) as a result of activities in the adjoining or nearby sites. This applies whether the holders of the permits are the same or different operators, and whether the operations covered by the two permits are at the same or different stages of their lifecycles.

1.7.5 Where there are areas of historic radioactive contamination or previously permitted disposals of radioactive waste, adjacent or near to the site, the SWESC should include any potential combined impacts on any representative persons as a result of the contributions from these sources, unless the levels of activity are out-of-scope of RSR.

2. Meeting our requirements

2.1 Introduction

2.1.1 This section gives an overview of how the operator of a nuclear site should demonstrate that:

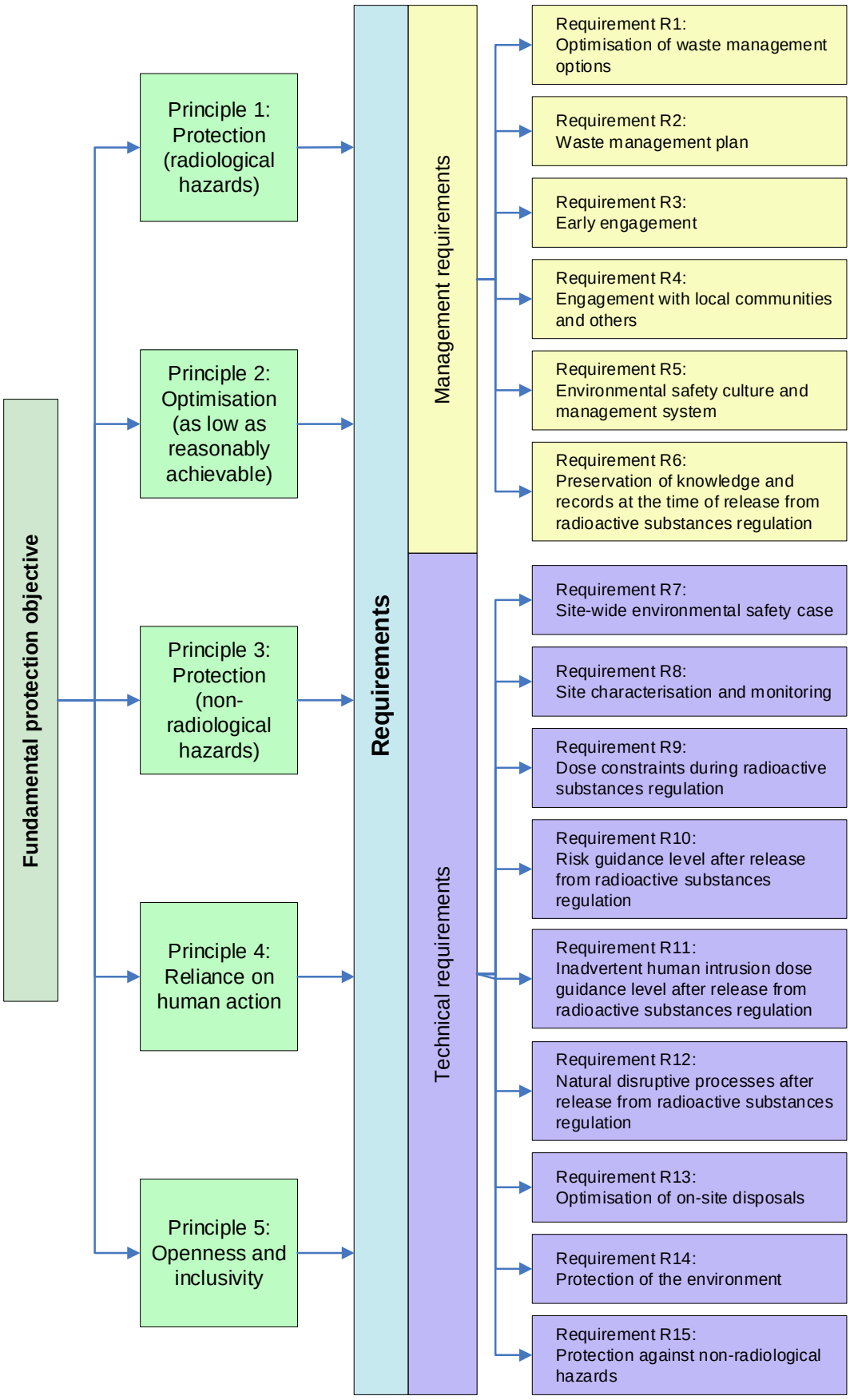
- our requirements have been met through their WMP and SWESC;
- they have used optimisation in their decision-making; and
- people and the environment are protected both now and in the future.

2.1.2 The operator should read Annex A in its entirety to fully understand our requirements.

2.1.3 Our fundamental protection objective (see para 1.3.1 and Annex A) and our principles reflect our primary aims in regulating nuclear sites. Our requirements are deliberately more specific to enable the operator to provide evidence that they have been met. Figure 2 shows how our principles and requirements relate to each other and how they support our fundamental protection objective.

2.1.4 Operators should demonstrate that they have met all the requirements set out in this guidance before we can release their site from RSR. However, the operator's demonstration should be proportionate to the radiological, and any associated non-radiological, hazards that they intend to reduce or remove, or to leave on or adjacent to the site.

Figure 2: Relationship between protection objective principles and requirements



2.2 Release from radioactive substances regulation (RSR)

2.2.1 Operators may apply for release from RSR for part or all of a nuclear site. We expect the operator to apply only when the site (or part of the site) is close to achieving the reference state.

2.2.2 The detailed application process differs between Scotland, and England and Wales; for further advice contact the relevant environment agency. The following describes the general approach to release from RSR across Great Britain.

2.2.3 We will only agree to release a site from RSR when the operator has demonstrated that:

- all disposals of radioactive waste on or from the site have definitively ceased; and
- the site reference state has been achieved.

2.2.4 If an operator applies for partial surrender, they must show that disposals of radioactive waste have definitively ceased on or from the part of the site covered by their application, and that no further work in that part will be required for the site as a whole to meet our standards.

2.2.5 We will not normally agree to partial release of a site if this leaves a number of physically separate parts of the original site still subject to RSR. This fragmentation might interfere with our regulation and with the operator's own controls.

2.2.6 The operator must demonstrate that the site as a whole will meet our protection standards at full and final release from RSR. The SWESC should take account of all relevant sources of radioactive substances and potential receptors. The geographical area considered by the SWESC will therefore need to extend beyond the boundary of the authorised premises. Any part of the site, that has previously been released from RSR and which has levels of radionuclides that do not exceed the RSR out-of-scope values, need not be considered further. Where the radionuclide concentrations are above out-of-scope values, their contribution to the total dose received by members of the public must be assessed.

Definitive cessation of RSR activities

2.2.7 RSR activities will have definitively ceased only when:

- all activities on-site involving the production, receipt or disposal of radioactive waste have permanently ceased, and have not just been deferred; and
- there is no waste on-site awaiting disposal (whether for disposal on-site or for transfer off-site).

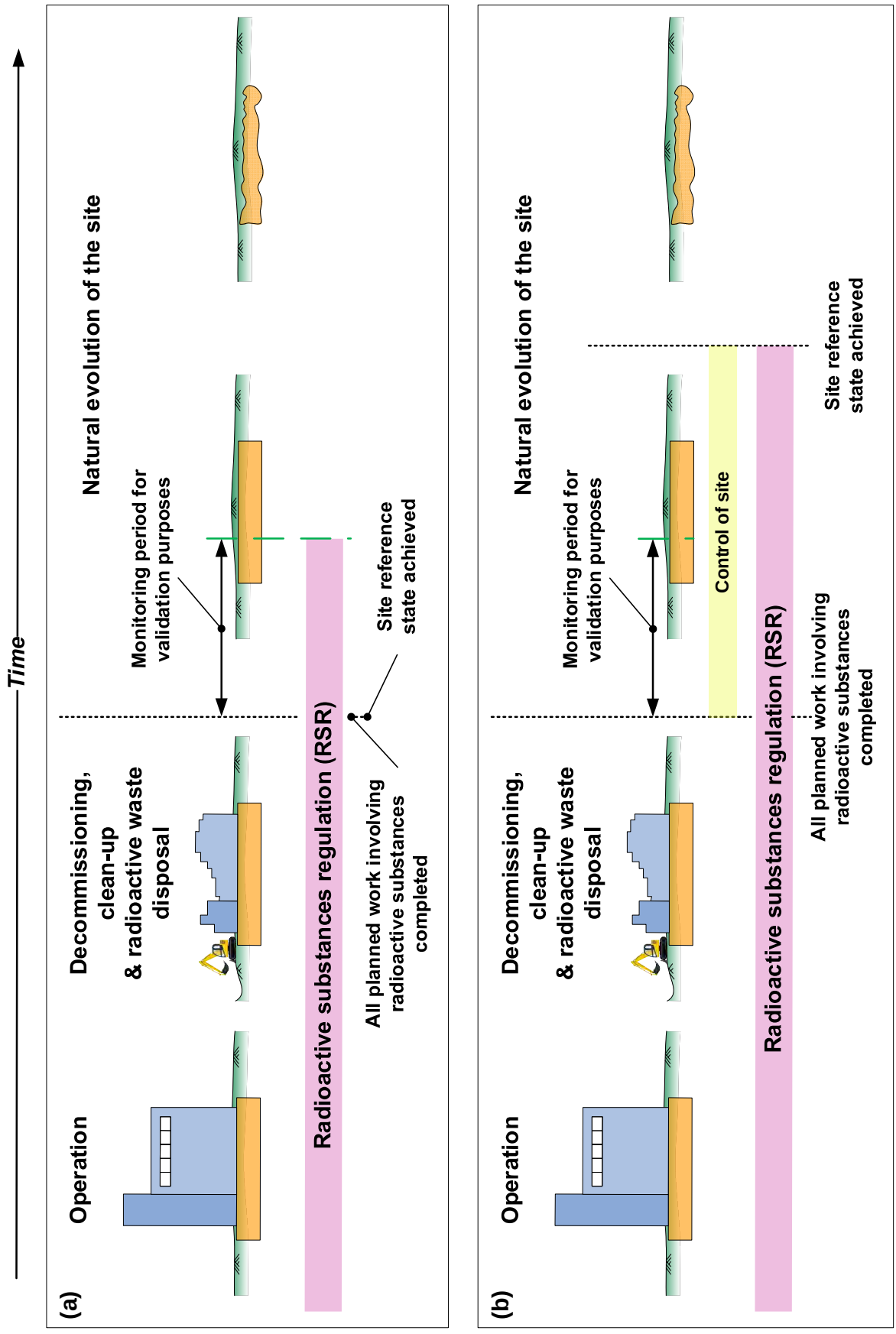
2.2.8 Radioactive waste awaiting disposal means radioactive waste that has not yet been lawfully disposed of by transfer off-site, or by on-site burial, deposit or leaving in situ in accordance with the operator's RSR permit. Radioactive waste lawfully disposed of on-site remains radioactive waste until the site is released from RSR.

2.2.9 Once the operator has ceased all planned work involving radioactive substances, the site will be in a condition that either:

- immediately meets our standards for release from RSR (Figure 3(a)); or

- requires a period of control to protect people and the environment until radioactive decay and other attenuation processes allow the site to meet our standards for release from RSR (Figure 3(b)).

Figure 3 Pathways to achieving the site reference state and release from RSR



Meeting our standards for release

2.2.10 'Site reference state' means the condition in which a site meets the standards in this guidance for release from RSR.

2.2.11 The site reference state is achieved when the SWESC shows that the residual risks presented by radioactive substances remaining on-site (if any) are, and will continue to be, consistent with our risk and dose guidance levels, without the need for controls.

2.2.12 We will only grant release of a site from RSR once operators have demonstrated that the site reference state has been achieved. In most cases we anticipate that this demonstration will require a period of validation monitoring (Annex A Requirement R8) before release from RSR (see Figure 3).

2.2.13 For simplicity, we presume that any site (or part of a site) in which levels of radionuclides do not exceed the RSR out-of-scope values, meets the standard for release from RSR. If the operator can demonstrate that this is the case, we consider our standard has been met without the need for further radiological assessment. This does not mean we expect that all sites should be cleaned up to below out-of-scope values.

2.2.14 Our standards for the period after release from RSR allow for any use of the site. However, regulation of land use at the site remains a matter for the relevant planning authority.

Period of control for the purpose of radiological protection

2.2.15 An operator's optimised WMP and SWESC may lead them to decide that a nuclear site will not immediately achieve the site reference state after all planned work involving radioactive substances is complete. In this case, the site will require a period of control for the purpose of radiological protection of people and the environment, until radioactive decay and other attenuation processes allow the site to meet our standards for release from RSR (see Figure 3(b)).

2.2.16 The duration of a period of control for the purpose of radiological protection, and the forms of control needed, will depend on a number of factors, such as the amount and type of radioactive substances remaining on site, and the potential impacts on people and the environment.

2.2.17 If an operator's WMP and SWESC rely on a period of control for the purpose of radiological protection, they must demonstrate that:

- the proposed controls will deliver the required protection; and
- the arrangements for applying controls can be maintained for the duration of the period of control.

2.2.18 Controls might take a variety of forms, such as signage, fencing, surveillance, maintaining drainage systems, maintaining records, and so on, and in any combination. The type 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.

2.2.19 The operator must assess and specify the proposed duration of any period of control for the purpose of radiological protection. We are unlikely to accept a proposal for a

period of control of longer than 300 years, because of the major social changes that may take place over long periods of time.

2.2.20 The existence of an RSR permit does not itself preclude use of the site for other purposes, including use of the site by a third party. However, the operator (permit holder) must continue to comply with the conditions of the permit while it remains in force.

2.2.21 We normally expect the operator to apply for release from RSR towards the end of the period of control for the purpose of radiological protection, when the site (or part of the site) is close to achieving the site reference state.

2.2.22 All controls that rely on action by people must have come to an end before the site is released from RSR.

2.3 Waste Management Plan and Site-Wide Environmental Safety Case

2.3.1 The operator must produce and maintain:

- an optimised waste management plan (WMP) setting out their intent for dealing with all the radioactive substances on or adjacent to the site (0 Requirement R2); and
- a site-wide environmental safety case (SWESC) demonstrating that people and the environment are now, and will continue to be, adequately protected from the radiological hazard and any non-radiological hazards associated with the radioactive substances remaining on or adjacent to the site (0 Requirement R7).

2.3.2 The glossary defines the WMP and SWESC. Sections 3 and 4 give further details of their scope and content.

2.3.3 The operator should have a clear strategy to support the development of their WMP and SWESC; a safety strategy (IAEA, 2012). The strategy is a high-level integrated approach comprising an overall management strategy for the various activities required to ensure that WMP and SWESC are properly coordinated and that they address all relevant considerations.

2.3.4 The operator must develop the WMP using an optimisation process (see section 2.5 and 0 Requirements R1 and R13) to decide the best overall management option for all radioactive waste and radioactive contamination on or adjacent to the site. This process should ensure that the operator's waste management choices consider the effects on people and the environment as a whole, while taking account of site-specific issues.

2.3.5 The WMP should describe how decommissioning wastes, including any arising from clean-up of radioactive contamination, will be managed to bring the site to a condition at which it can be released from RSR. If the optimisation process identifies that waste is best managed by disposal on-site, the details of any proposed waste disposal should be assessed in the SWESC.

2.3.6 The SWESC should demonstrate the safety of all radioactive substances (above RSR out-of-scope values) that the operator proposes to leave on or adjacent to the site, whether radioactive waste or radioactive contamination. In this way the SWESC should show that the site can meet the standards in this guidance. The SWESC will

also demonstrate that the management of non-radioactive hazards associated with the radioactive waste protects people and the environment.

2.3.7 The operator should prepare the WMP and SWESC as soon as reasonably practicable, and keep them up-to-date. The operator should agree with the relevant environmental regulator the frequency of updates.

2.3.8 Figure 4 shows the duration of the WMP and SWESC against the timeline for a decommissioning site, where the operator uses a period of control for the purposes of radiological protection. The WMP should be maintained and implemented until all planned work involving radioactive substances is completed. The SWESC should be maintained until the site is released from RSR.

2.3.9 The WMP and SWESC can consist of a collection of resources that together meet our requirements. We do not require operators necessarily to produce dedicated documentation, other than, as a minimum, 'head' or signposting documents.

2.3.10 The WMP and SWESC should take account of all planned work associated with bringing the site to a condition at which it can be released from RSR.

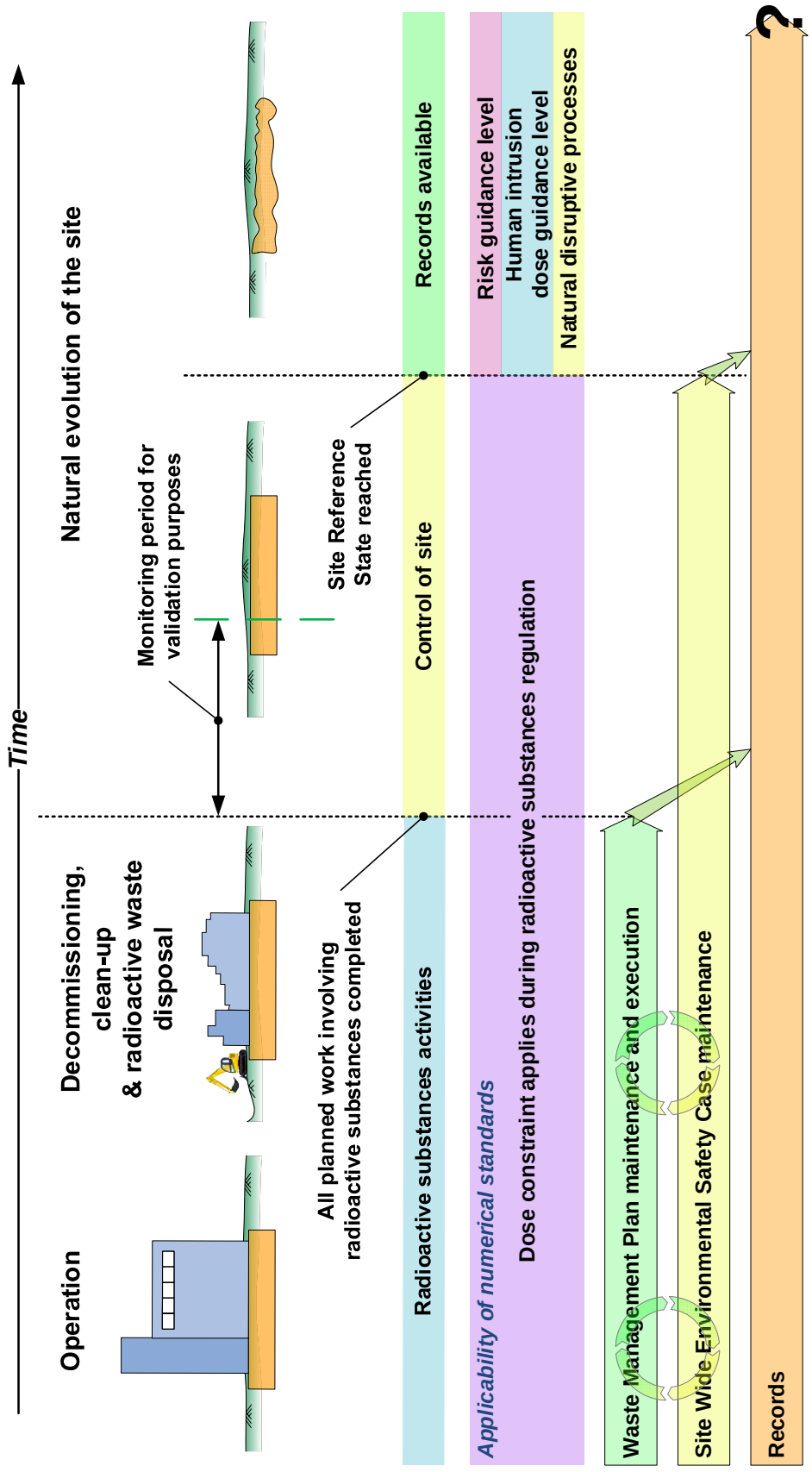
2.3.11 The WMP and SWESC should also take full account of any period during which work on decommissioning and clean-up is deferred, and the work planned to resume after that period. In particular, they should demonstrate that all radioactive waste or radioactive contamination that remain on-site, awaiting resumption of work, will be adequately monitored and controlled during that period. This is to minimise migration of radioactive substances into or through the environment during that period. The WMP should also consider the extent to which physical or chemical changes to radioactive waste or radioactive contamination during that period might affect the ability to retrieve it or clean it up.

2.3.12 The operator must submit a WMP, supported by a SWESC, if applying for authorisation to dispose of waste on-site (see 2.5). We will only authorise the disposal of radioactive waste on-site if operators demonstrate, through the WMP and the SWESC, that such disposals are optimised, safe and meet all of the requirements specified in this guidance. We expect the WMP and SWESC to be sufficiently comprehensive at the time of application to allow the relevant environment agency to make a decision, but we recognise that they may continue to evolve.

2.3.13 The operator must provide a complete and up to date SWESC in support of an application for release from RSR demonstrating that all of the requirements in this guidance have been met. We will only release the site from regulation when we are satisfied with the SWESC.

2.3.14 Operators should make proportionate use of independent peer review to build confidence in their WMP and SWESC. The experts undertaking the peer review should have no direct interest (for example, political, reputational or commercial interest) in the outcome of the WMP and SWESC.

Figure 4 Milestones in decommissioning and evolution of the site: Timeline for application of requirements of this guidance



2.4 Our numerical standards

2.4.1 Four of our requirements specify our numerical standards for radiological protection (see Annex A Requirements R9 to R12). Figure 4 shows when these requirements apply at different stages in the timeline of a site.

2.4.2 Requirement R9 (dose constraint) applies at all times before release from RSR, because the site is under the operator's control, and is regulated by us.

2.4.3 After release from RSR, Requirement R9 no longer applies. Instead, Requirement R10 (risk guidance level), Requirement R11 (inadvertent human intrusion dose guidance level) and Requirement R12 (natural disruptive processes), all apply. These requirements are forward-looking and do not depend on continuing operator control or regulatory oversight.

2.4.4 The international and national basis for these numerical requirements is discussed in Annex B.

2.5 Waste management options and optimisation of disposals

2.5.1 In regulating radioactive waste disposal on or from nuclear sites, we must ensure that exposures of members of the public to ionising radiation are kept below statutory limits and constraints. Moreover, below these limits and constraints, we must ensure that operators keep these exposures as low as reasonably achievable (ALARA), taking into account economic and social factors. This is referred to as 'optimisation', an essential principle in radiological protection. Optimisation seeks to keep the radiation exposure of people as low as possible, while ensuring that the costs and other detriments of doing so are not disproportionate.

2.5.2 Operators must apply optimisation when managing radioactive waste from decommissioning and clean-up at their sites, to give the best overall result for people, the environment and society as a whole.

2.5.3 Successful optimisation ensures a suitably low level of risk from radiation exposure, but does not necessarily require the lowest possible risk. Optimisation in 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 radioactive substances being removed from a site.

2.5.4 Our guidance therefore gives the operators of different nuclear sites flexibility to make different decisions about the amounts and types of radioactive waste or contamination they plan to remove for disposal at facilities elsewhere, or to leave on or adjacent to their site. These decisions must take full account of all relevant factors, and protect members of the public and the environment. The final condition of the site must meet our standards for release from RSR.

2.5.5 We express optimisation through two requirements that emphasise different aspects of the principle that apply at different times in the management of radioactive wastes and radioactive contamination (see Annex A, Requirements R1 and R13).

2.5.6 Requirement R1 requires the operator to carry out a systematic and iterative options assessment for each of their radioactive wastes, to identify the management option that, when considered in combination with the management options for all other radioactive wastes and radioactive contamination at the site, ensures overall exposures of people are ALARA. Figure 5 shows some examples of potential

management options for decommissioning nuclear sites. Where the operator demonstrates an on-site disposal option is optimal, Requirement R13 requires the operator to consider what more can be done in the specific design, construction and implementation of that disposal, to ensure exposures are ALARA.

2.6 Authorisation of on-site disposals

2.6.1 Operators must be authorised by us before they can dispose of radioactive waste on-site, whether by emplacing waste or leaving it in situ. We will take appropriate enforcement action for any unauthorised disposal of radioactive waste.

2.6.2 Operators must obtain authorisation to dispose of radioactive waste on-site by applying for a variation to the site permit. An application for such a variation should be accompanied by:

- the WMP describing the proposed disposals, including options assessments demonstrating that these represent the optimised solution; and
- the SWESC demonstrating that the disposals can be made in compliance with the requirements of this guidance and that the site will reach a condition where it can be released from RSR, and will do so within an acceptable period of time.

2.6.3 Applications for authorisation should also take account of relevant guidance for non-radioactive waste to demonstrate an equivalent level of protection from any non-radioactive hazards associated with radioactive waste.

2.6.4 It is up to operators to decide when to apply for authorisation for on-site disposals. However, we encourage operators to apply as early as is reasonably practicable. We also encourage operators to ensure their applications are as comprehensive as possible, covering waste that exists and that is expected to arise. This should minimise the number of separate applications, and the administrative burden, on operators and us.

2.6.5 Operators should apply for subsequent permit variations if they propose changes to the on-site disposals set out in the WMP.

2.6.6 Operators should consult the guidance note ‘Disposal of radioactive waste by deposit or burial: Joint Regulators' Statement of Common Understanding’ (EA, SEPA, NRW & ONR, 2016) for further information on how we will work with ONR to achieve a harmonised approach to on-site disposal of radioactive waste.

<u>On-site disposal of radioactive waste in a dedicated disposal facility</u>

2.6.7 An operator may apply for authorisation to dispose of radioactive waste to a dedicated near-surface on-site disposal facility (see Figure 5(b)). For full guidance on the environment agencies’ requirements for authorisation of such a facility, operators should refer to our guidance ‘Near-surface Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation’ (NS-GRA) (EA et al., 2009).

2.6.8 Such a dedicated radioactive waste disposal facility will require its own environmental safety case (ESC), in line with the provisions of the NS-GRA. 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 waste in situ

2.6.9 An operator may apply for authorisation to dispose of radioactive waste, such as a buried object or structure, by leaving it permanently in situ (see Figure 5 (c) & (d)).

2.6.10 The operator must make timely assessments of the optimised disposal options for buried radioactive waste, i.e. whether and how to dispose of it in situ, or to retrieve and dispose of it in some other manner. The operator should therefore set out their intentions in the WMP at the earliest opportunity. Defining the act of disposal and its timing, and therefore the timing of an application for authorisation, is likely to require discussion between the operator and the relevant environment agency.

2.6.11 We may conclude that the operator has disposed of waste in situ if:

- they have not declared any intent to retrieve the waste in the WMP; or
- their declared intent to retrieve the waste is unfeasible or we believe it is unlikely to be implemented.

On-site disposal of radioactive waste for a purpose

2.6.12 An operator may apply for authorisation to dispose of radioactive waste on-site for a purpose (see Figure 5(e), (f) & (g)) such as:

- making land safe, for example by filling voids
- constructing roads, tracks and hard-standing
- constructing bunds, barriers or screens
- landscaping to comply with local planning authority requirements

2.6.13 If proposing to dispose of radioactive waste for one of these purposes, in addition to demonstrating that the disposal is in accordance with the requirements in this guidance, the operator should also demonstrate that the waste has a suitable physical and chemical specification and replaces material that would otherwise be needed for that purpose. Any works must be done in accordance with relevant legislation, and should also be in accordance with good engineering standards and good practice.

2.6.14 There is no equivalent in RSR to the concept of 'recovery', as used in the Waste Framework Directive. Radioactive waste disposed of on-site for a purpose remains radioactive waste until the site is released from RSR. There are a range of approaches to the classification, reuse, and disposal of non-radioactive excavated material that may be applicable to materials management on decommissioning nuclear sites. For example, the Development Industry Definition of Waste Code of Practice (DoWCoP) sets out good practice for the development industry to use in assessing, on a site-specific basis, whether the re-use of excavated materials is classified as a directive waste activity or not, and when treated excavated directive waste can be re-used for a particular purpose (CL:AIRE, 2011). Operators should discuss their plans for excavated material with the relevant environment agency to confirm whether a permit is required and, if so, the type of permit.

Making use of radioactive decay

2.6.15 An operator may plan to make use of radioactive decay in optimising the management of radioactive waste, to facilitate its eventual disposal. The operator must declare any such intention in the WMP, and demonstrate how this is the optimised management option for that waste.

2.6.16 We will only accept plans for delaying disposal through the use of decay if the operator intends to remove the waste from the site. The operator must have a credible plan to retrieve and transfer the waste for disposal at another authorised facility, as soon as practicable after the waste has decayed enough to enable transfer.

2.6.17 If the operator has no credible plan to retrieve and transfer waste after the period of decay, we regard this as a de facto decision to dispose of the radioactive waste in situ. We expect operators to declare this intention in the WMP and to apply in a timely manner for authorisation of the on-site disposal.

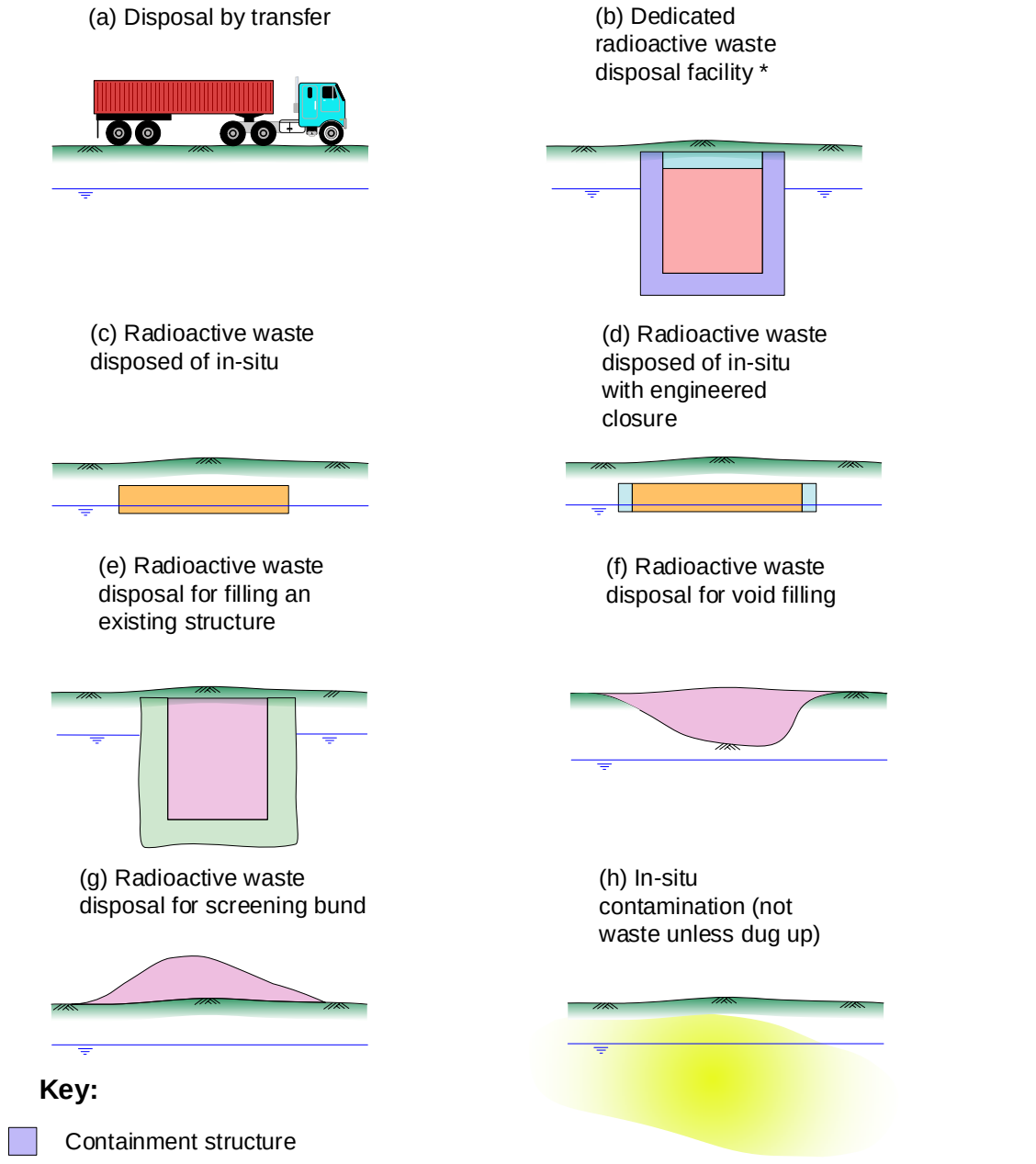
2.6.18 The operator must adequately control radioactive substances to minimise migration into or through the environment during the period of radioactive decay, and must consider whether physical or chemical changes to the waste might affect the ability to retrieve it.

2.6.19 If the operator proposes to use radioactive decay to facilitate the eventual disposal of a redundant structure, it must be adequately maintained to protect people and the environment prior to its retrieval.

2.6.20 Waste being stored for the purpose of decay is regulated by ONR as an accumulation. It must be managed under the appropriate safety case, and operators must comply with the relevant nuclear site licence conditions.

2.6.21 If the waste has decayed to levels of radioactivity that are out-of-scope of RSR at the time of any retrieval and transfer, it will be subject to legislation which implements the Waste Framework Directive and must be dealt with accordingly (see Section 5.4).

Figure 5 Potential management options for radioactive substances from the final stages of decommissioning of nuclear sites



Note: The position of the water table in this figure is illustrative only and should not be taken to indicate that disposals of radioactive waste in the saturated zone would always be authorised. Each proposed disposal of radioactive waste must be individually assessed to determine whether any potential input to groundwater is direct or indirect. Direct inputs of pollutants into groundwater are prohibited unless certain criteria set out in legislation are met.

3. Waste management plan (WMP) (Requirement R2)

3.1 Introduction

3.1.1 The operator of a nuclear site should produce and maintain a WMP to manage the programme of disposals of radioactive waste until work involving radioactive substances is completed. This section provides further details of our expectations for the WMP.

3.2 Purpose of the WMP

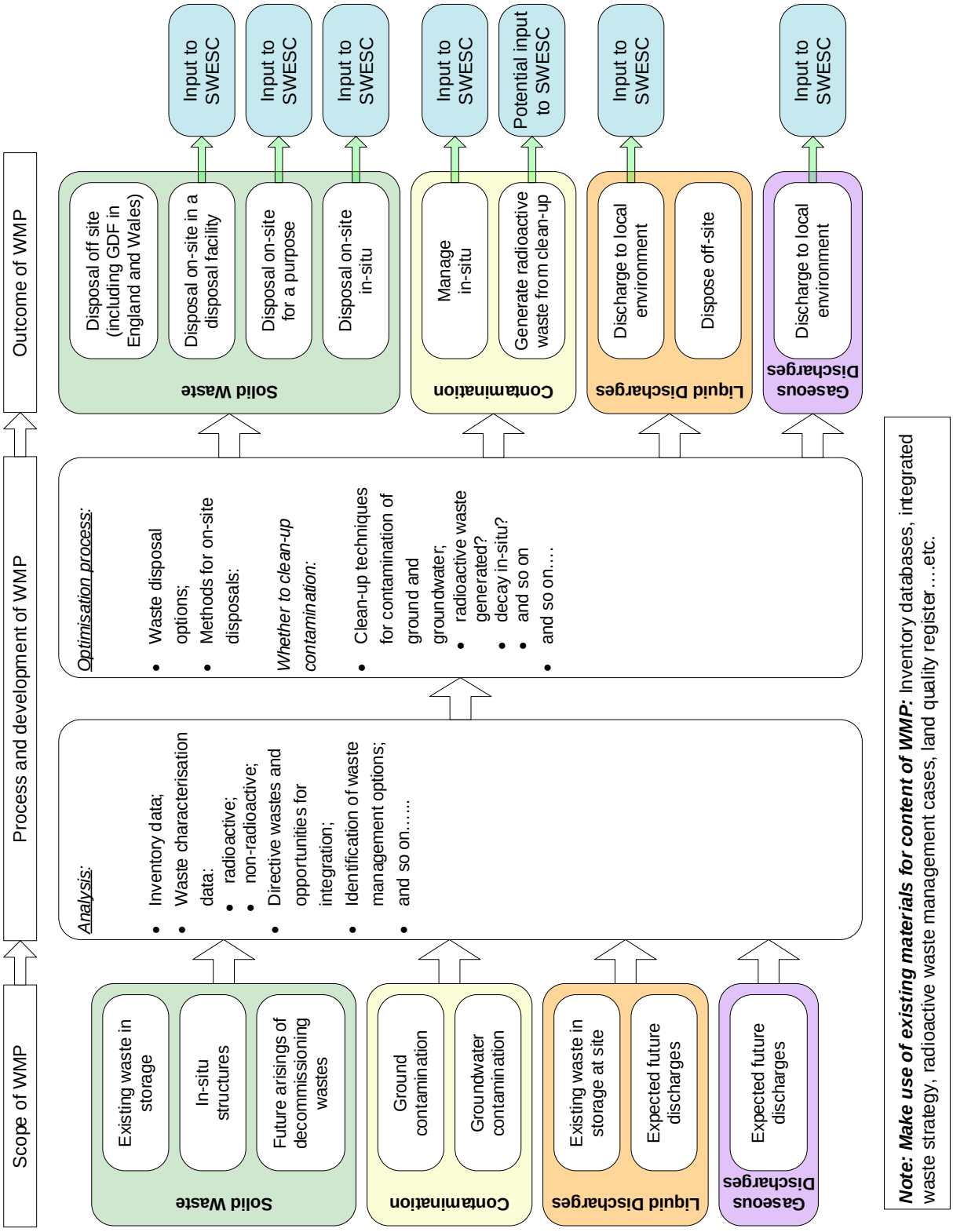
3.2.1 The WMP required by Requirement R2 is a practical plan to manage the programme of disposals of radioactive waste arising from a site. The WMP is implemented until work involving radioactive substances is completed to achieve the site reference state. The site reference state will either be achieved immediately after such work is complete, or after a period of control for the purpose of radiological protection (see Figure 3).

3.2.2 The WMP has three principal aims. It should:

- show that radioactive waste management is optimised
- describe how the site will be brought to a condition that meets our requirements for release from RSR
- support the arguments and claims presented in the SWESC

3.2.3 Figure 6 gives an overview of the WMP showing the inputs, analysis and outputs of the plan. These outputs should be an optimised set of decisions about how the operator will manage all radioactive waste and contamination during decommissioning and clean-up at the site. If the operator proposes to dispose of radioactive waste or to leave radioactive contamination on or adjacent to their site, sufficient information should be included in the SWESC to enable adequate assessment of the impacts upon people and the environment.

Figure 6 Overview of the waste management plan



3.3 Scope of the WMP

3.3.1 The WMP should cover all existing radioactive wastes, and those radioactive wastes anticipated to arise in the future, from planned decommissioning and clean-up of radioactively contaminated ground and groundwater.

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

- disposal by transfer off-site
- disposal by emplacement on-site, such as into an on-site waste disposal facility or for a purpose, such as void filling
- disposal by deliberately leaving waste in situ
- disposal of liquid and gaseous waste by discharge to the local environment

3.3.3 Any off-site disposals of radioactive waste must be made to an authorised facility.

3.3.4 The WMP and SWESC should also cover any waste and contamination associated with discharge pipelines that may pass through land not owned by the operator, or may extend many kilometres to remote discharge points.

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

3.3.6 We strongly encourage the WMP to take an integrated approach to the management of all wastes, both radioactive and non-radioactive, over the lifetime of the site. But it should give priority to ensuring an optimised outcome for the radioactive wastes. This is discussed further later in this section.

Legal considerations regarding scope of the WMP

3.3.7 Any substance or article that has been used by the operator for the purpose of their authorised undertaking is likely to become radioactive waste when no longer used, if it contains or is contaminated with radioactive substances above the RSR out-of-scope values (RSA 93 and EPR 2016; see also Defra et al., 2011).

3.3.8 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 radioactive substances.

3.3.9 Radioactive waste is subject to different legislation to that for non-radioactive waste. RSR legislation in the UK transposes Directive 2013/59/Euratom (EC, 2013)) whose primary aim is the protection of people from ionising radiation. UK legislation governing non-radioactive waste (directive waste) transposes the Waste Framework Directive (see Section 5.4). This Directive aims to protect people and the environment from the negative impact of waste, while promoting the conservation of natural resources, through the establishment of a waste hierarchy.

3.3.10 Ground or groundwater contaminated with radioactive substances (from past leaks, for example) is not regarded as waste, unless and until it is removed by some operation. Any such waste arising will then be radioactive waste if it contains radionuclides at concentrations above the out-of-scope values. If the WMP shows

that it is optimal to clean-up contamination to reduce radiological or non-radiological risks, then any radioactive wastes that arise must be included in the WMP. The operator must identify optimised disposal routes for their disposal.

3.4 Considerations for the content of the WMP

Characterisation

3.4.1 The operator should characterise radioactive waste before and during its production and disposal (see Annex A Requirement R8). This characterisation should be sufficient to inform decision making about decommissioning and clean-up and managing the production and disposal of any radioactive waste.

3.4.2 The operator should characterise structures such as buildings, vessels and pipes that may be contaminated from previous operations, or from leaks or spills. The operator's characterisation work should take account of the variation in degree and nature of contamination over the whole of a structure.

3.4.3 The operator should characterise all waste in a way that recognises that some parts may be below the RSR out-of-scope values, while other parts may be above these values. The operator should segregate and sentence all waste appropriately to ensure their management of the waste is optimised.

3.4.4 We generally would not accept simple averaging of the estimated activity over the total mass of the waste. The nuclear industry has published its own guide (Nuclear Industry Safety Directors' Forum, 2017) which describes characterisation and sentencing for clearance and exemption in more detail.

3.4.5 If the outcome of characterisation is that the waste is out-of-scope of RSR, it will be directive waste and must be managed in compliance with the relevant directive waste requirements.

Integrated waste management

3.4.6 The operator should demonstrate integrated planning for the management of both radioactive and directive waste. This planning should take into account all current and expected future arisings of radioactive and directive wastes, and their radiological and non-radiological properties. The waste management hierarchy should be applied, as appropriate. The operator should thereby maintain a clear strategic overview of how they intend to manage the production and disposal of waste over the lifetime of the facility.

3.4.7 This approach is necessary to ensure that relevant statutory, government policy and other regulatory requirements are met in an integrated and efficient way, and to ensure that people and the environment are properly protected against both the radiological and non-radiological properties of the waste. The WMP should refer to, and be consistent with, relevant integrated waste management plans and strategies.

3.4.8 Such planning should seek to ensure that decommissioning and clean-up are carried out so as to (a) minimise waste production and (b) facilitate the management, recovery (where applicable) and disposal of those wastes that are produced in accordance with legislation and government policy. For radioactive wastes, this includes considerations such as:

- the segregation of wastes to maximise the volume of waste that is directive waste and minimise the volume of radioactive waste
- the appropriate use of exemptions for radioactive waste
- for LLW, the requirements of the LLW policy (Defra, 2007) in general, including the need for early solutions for radioactive waste disposal in particular
- for radioactive 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 radioactive wastes, the requirement for operators to produce Radioactive Waste Management Cases (RWMCs) (ONR et al., 2015)

Minimisation of secondary waste

3.4.9 Decommissioning and clean-up activities involving radioactive waste or radioactive contamination, may contaminate other substances or articles, and so produce 'secondary wastes'. Operators' RSR permits require them to avoid or minimise the production of such wastes.

3.4.10 The WMP should demonstrate that all radioactive waste on site is adequately controlled. This means 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 contamination in the ground and groundwater. This applies to all wastes, whether held in engineered stores, buried in situ, awaiting retrieval or in open stockpiles.

3.4.11 If radioactive waste is stored in a dedicated storage facility, the waste should be packaged and the facility designed and operated to prevent escape of radioactive substances and to minimise production of radioactive waste when the store is eventually decommissioned.

3.4.12 If operators propose to leave radioactive waste in situ for a period of time or to accumulate it in open stockpiles, prior to its final disposal, they must demonstrate that:

- any migration of radioactive substances into the environment during accumulation is acceptably low; and
- the radioactive waste is geotechnically stable, and not at risk of erosion.

3.5 Format of the WMP

3.5.1 The WMP does not have to be a single document prepared solely to meet this guidance or any associated permit condition. It can comprise a collection of resources that are already in place, such as inventories of existing wastes and schedules of future waste arisings; the contents of the Integrated Waste Strategy for the site may be relevant, and it can refer out to RWMCs for higher activity wastes. The WMP should be sufficiently comprehensive and detailed to meet the purposes stated above, taking account of the history and complexity of the site concerned. Additional material may need to be assembled in relation to the following aspects, which may not be covered in existing documentation:

- optimisation studies demonstrating how the radioactive waste management proposals have been determined to be optimal; and

- a full inventory of both radioactive waste and radioactive contamination proposed to remain on-site after all planned work involving radioactive substances is completed.

3.6 Maintaining the WMP

3.6.1 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.

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

- achievement of significant milestones in progress towards the completion of all planned work involving radioactive substances
- 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 radiation doses to people or the environment
- the requirement to maintain currency and best practice
- the requirement to maintain consistency with the SWESC

3.6.3 If the WMP is revised the operator should inform us of any changes that materially affect the SWESC.

3.6.4 The operator should also maintain a SWESC (see Annex A Requirement R7 and Section 4) that demonstrates how the WMP is consistent with bringing the site to a condition at which it can be released from RSR, by achieving the site reference state as soon as reasonably practicable after all planned work involving radioactive substances has been completed.

3.6.5 We recognise that the operator may not initially have the necessary information to identify and characterise waste and select optimised disposal routes for all radioactive wastes that might arise. In such a case the operator should demonstrate that they have 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.

3.6.6 At each decision-making stage (i.e. when the decommissioning plan is significantly changed), the operator should make a written record that they have properly considered optimisation. The operator should also maintain, as part of the WMP, a record of the decisions they have taken and implemented, and the optimisation considerations that contributed to those decisions when they were taken. This record should be as compete as possible, acknowledging that past decisions (prior to this guidance) may not always have been fully documented.

3.6.7 The WMP should be maintained, as a minimum, up to the point when all planned work involving radioactive substances has been completed. On those sites that are relying on a period of control for the purposes of radiological protection, other activities such as new construction may require the WMP to be revisited if the changes on the site are significant.

4. Site-wide environmental safety case (SWESC) (Requirement R7)

4.1 Introduction

4.1.1 The operator should produce and maintain a SWESC to demonstrate that the health of members of the public and the integrity of the environment will be adequately protected, both during and after RSR. This section provides further details of our expectations for the SWESC.

4.2 Purpose of the SWESC

4.2.1 The SWESC (required by Requirement R7 see Annex A) 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 achieved.

4.2.2 The SWESC should reflect progress in the implementation of the WMP and should be sufficiently comprehensive and robust to provide adequate confidence in the environmental safety of the site. It should take 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
- that will remain on or adjacent to the site when all planned work involving radioactive substances is complete.

4.2.3 The SWESC should demonstrate a clear understanding of the site throughout the period of RSR and its subsequent evolution after release from RSR.

4.2.4 The SWESC should be designed to demonstrate consistency with the principles and show that the management and technical requirements are met (see Annex A). In particular, the operator must demonstrate through the SWESC how the site meets our requirements for protection of people and the environment from radiological and the associated non-radiological hazards, both now and in the future.

4.3 Scope of the SWESC

4.3.1 The SWESC should include the claims, arguments and evidence needed to support an application for release from RSR. To do so, the SWESC must demonstrate the environmental safety of:

- the present condition of the site, and site conditions that might occur before eventual release from RSR, by meeting Requirement R9 (dose constraint); and
- future conditions of the site after release from RSR, by meeting Requirement R10 (risk guidance level), Requirement R11 (inadvertent human intrusion dose guidance level) and Requirement R12 (natural disruptive processes).

4.3.2 The SWESC should take account of all radioactive substances (whether disposed waste or contaminated ground or groundwater) remaining on and adjacent to the site.

4.3.3 The NS-GRA (EA et al., 2009) will apply to any dedicated near-surface radioactive waste disposal facility on-site, whether existing or proposed. Any such facility will require its own environmental safety case (ESC). The SWESC must take full account of the risks assessed in any facility-specific ESC.

4.3.4 The SWESC should describe all aspects of the site setting and conditions (often referred to as the conceptual site model (CSM)) that may affect environmental safety, including but not limited to:

- geology
- hydrogeology and hydrology
- biosphere
- surface features and conditions
- climate
- characteristics of any radioactive substances remaining on site
- relevant engineering features

4.3.5 The SWESC should include quantitative environmental safety assessments for both the period of RSR and afterwards. These assessments should extend sufficiently into the future to provide reasonable confidence that they cover the peak radiological risks (for example, from delayed releases of activity from disposals). But they should not be extended beyond a time when uncertainties have become so great that quantitative assessments cease to be meaningful. These assessments should explore the consequences not only of the expected evolution of the site after release from RSR, but also of less likely evolutions and events.

4.3.6 The SWESC should take into account the potential consequences of climate and landscape change. There is considerable uncertainty regarding such changes, in particular the rate, amount and even the direction of climate change over different timescales. So the operator should consider a range of scenarios, using robust sources of data and projections, to explain their choice of scenarios.

4.3.7 The SWESC should consider the possibility and consequences of a criticality event. However, no more than negligible amounts of fissile material should remain at a site that has been satisfactorily decommissioned and cleaned up. Therefore a simple analysis, with appropriate evidence, should be sufficient to demonstrate that such an event will not occur.

4.3.8 The operator should maintain a SWESC whose complexity is proportionate to the hazards involved. A simple SWESC may be adequate for a site where the operator can easily demonstrate that only very low concentrations or quantities of radioactive substances need to be managed. The SWESC will increase in complexity where there is contamination of ground or groundwater by radioactive substances, and/or where the operator proposes to dispose of radioactive waste on site.

4.3.9 To ensure that they produce a SWESC that is proportionate to the hazards involved, the operator may choose to adopt a step-wise approach to its development. If their optimisation processes support on-site disposal or leaving contamination in-situ, they may find it useful to carry out an initial screening assessment of the likely impacts of any hazards remaining on or adjacent to the site. The operator may begin early discussions with us over the results of their screening assessments, which in turn could be used to guide the development of subsequent versions of their SWESC.

4.4 Considerations for the content of the SWESC

4.4.1 The SWESC should demonstrate that the operator has identified all uncertainties and biases that may have a significant effect on environmental safety. The operator should take all reasonable steps to remove or reduce them, to improve confidence in the environmental safety of the site.

4.4.2 The operator should provide robust and comprehensive evidence for any claim or assumption, which the SWESC relies upon to demonstrate environmental safety. We encourage the operator to discuss such claims and assumptions with us as they develop their SWESC.

4.4.3 The SWESC should describe the operator's arguments for having confidence in the case. These arguments should include (but not be limited 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 Annex A Requirement R6)

4.4.4 The complexity of the SWESC should be proportionate to the available data and level of technical understanding.

<u>Multiple lines of reasoning and complementary environmental safety arguments</u>

4.4.5 The operator should use quantitative environmental safety assessments to demonstrate consistency with our numerical standards (see Annex A Requirements R9-R12). However, the uncertainties inherent in these assessments may mean they can give only a broad indication of environmental safety.

4.4.6 The operator should therefore use additional means to satisfy us that people and the environment will be sufficiently protected. The SWESC should make proportionate use of multiple lines of reasoning, which lead to complementary environmental safety arguments. This may be particularly important when environmental safety must be assured over long periods of time. The reasoning, claims and assumptions in these arguments should be clear, and the evidence supporting them traceable. The evidence may be both qualitative and quantitative. The SWESC should bring complementary arguments together in a structured way.

4.4.7 The operator should complement the quantitative environmental safety assessments in the SWESC by making appropriate use of environmental safety indicators. These indicators might include radiation dose, radionuclide flux, radionuclide travel times or radiotoxicity.

4.4.8 Where the radiological hazard warrants it, operators should provide a wide range of information relating to such indicators, for example:

- radionuclide release characteristics from the waste or contamination
- concentrations in the accessible environment of radionuclides from the waste or contamination
- comparisons of such concentrations with naturally occurring levels of radioactivity
- assessment of collective radiological impact (as a measure of how widespread any significant increase in risk may be) - however, for more information on the use of collective dose see paras A3.13 to A3.15.

Managing uncertainties

4.4.9 Uncertainties will always be present in environmental safety assessments, and the operator needs to understand and manage them when developing the SWESC.

4.4.10 The operator should demonstrate that the SWESC takes adequate account of all uncertainties that have a significant effect on environmental safety, both before and after release from RSR.

4.4.11 The operator should identify significant uncertainties, and clearly explain the significance of them. The developing SWESC should include a strategy for managing them, by considering whether:

- they can be quantified, and to what extent; and
- they can be removed or reduced.

4.4.12 Some uncertainties are common to all radiological assessments. This is true for dosimetric data and risk coefficients recommended by advisory bodies. There is no reason to include these uncertainties explicitly in assessments supporting the SWESC.

4.4.13 Uncertainties may be either quantifiable or unquantifiable; the SWESC should deal with these different types of uncertainty appropriately.

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

4.4.15 Some uncertainties may not be quantifiable because reliable data are not available. These uncertainties 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.

4.4.16 Some uncertainties may be managed by making simplifying deterministic assumptions based on reasoned arguments. Because processes in the natural environment may be complex, some simplifications in assessments may be necessary. The operator should show that any simplifications either have no significant effect on the outcome of the assessment, or do not lead to impacts being underestimated.

Modelling studies and confidence-building

4.4.17 Modelling studies are likely to make up an important part of the quantitative environmental safety assessment. They may also support complementary arguments based on alternative lines of reasoning. As well as the results of the studies, operators should provide details of the models and methodologies used, including any assumptions and measures to verify, and where feasible, validate models.

4.4.18 The general aim of modelling studies will be to help in understanding the characteristics of the site and behaviour of substances in the local environment. If there are likely to be extensive modelling studies, we encourage the operator to consider discussing the modelling objectives with us at an early stage.

4.4.19 The operator should 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.

4.4.20 Models and associated parameter values should, if practicable, be site-specific. Any use of generic data instead of site-specific data should be shown not to lead to an underestimation of the effects. Using generic models and parameter values may be more appropriate to the early stages of developing the SWESC or where the radiological hazard is particularly low.

4.4.21 In some cases, there may be a number of alternative credible interpretations of the data, and no one conceptual model of the system can be regarded as uniquely valid. The operator should show that the SWESC is not unduly sensitive to alternative interpretations or conceptual models.

4.4.22 The operator should judge when it will be sensible to end the programme of building confidence in the modelling, and should record the basis for these judgements.

4.4.23 Computational models should be used appropriately. In particular, the model results will only be reliable within a range of input parameter values. The operator should demonstrate that each model used is appropriate for the conceptual site model, together with appropriate evidence.

4.4.24 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.

4.4.25 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. Examples of where this approach may be valid include the evolution of the biosphere and inadvertent human intrusion. If a stylised approach is used for modelling the site, or part of the site, the operator should ensure that this does not distort the modelling of the rest of the system, for example, by obscuring important properties of other parts of the system.

Use of expert judgement

4.4.26 Expert judgement is essential in gathering and interpreting evidence and in constructing and using 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.

4.4.27 Where the operator makes use of expert judgement that is not held in common, they 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
- 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

4.5 Maintaining the SWESC

4.5.1 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. They should update the SWESC at suitable intervals up to the release from RSR, and should comprehensively review the SWESC no less frequently than every 10 years. The SWESC, including any quantitative assessments within it, will need, at each stage, to be sufficiently detailed and comprehensive to inform and support the operators' decommissioning and clean-up programme in accordance with the WMP.

4.5.2 Updates to the SWESC should reflect growing knowledge about the site and should be consistent with the WMP. Updates should also take into account, for example, new characterisation data and feedback from regulators, together with developments in environmental safety assessment techniques, in radiological protection and in technical understanding. The eventual aim will be to show that people and the environment will be adequately protected when the site reference state has been achieved.

4.5.3 The operator should consider how their SWESC will be structured and updated to ensure traceability and transparency. They should also maintain a detailed audit trail of changes to the SWESC.

4.5.4 ONR has indicated that the SWESC may provide a suitable vehicle for the safety cases that the operator is required to maintain under nuclear safety legislation, provided that it can be clearly identified as such, and meets the requirements of ONR guidance.

5. Other regulations affecting decommissioning nuclear sites

5.1 Introduction

5.1.1 This section gives a brief overview of other key regulatory requirements that apply to nuclear sites. It does not attempt to describe all the applicable regulations, but focuses on those with the greatest interaction with RSR.

5.1.2 In the case of the groundwater legislation, described in section 5.2, it is the relevant environment agency's duty to ensure that with respect to radioactive substances, RSR permits deliver the requirements of the legislation.

5.1.3 It is the operator's responsibility to comply with the other relevant regulations described in sections 5.3 to 5.8, which apply independently of the RSR permit.

5.2 Groundwater protection and RSR

5.2.1 The EU Water Framework Directive (2000/60/EC; EC, 2000), and its daughter directive the Groundwater Directive (2006/118/EC; EC, 2006), are concerned with the protection of groundwater against pollution, prevention and limitation of inputs of pollutants to groundwater and prevention of deterioration of status of groundwater bodies. The Directives apply to the disposal of radioactive waste on or from nuclear sites and are a relevant consideration in determining whether a site should be released from RSR. The Directives are implemented in Scotland, Wales and England through several legislative instruments[2], referred to hereafter as groundwater protection legislation (see glossary).

5.2.2 In Scotland, Wales and England the regulatory provisions of the groundwater protection legislation for radioactive substances are delivered through RSR permits.

5.2.3 For the purposes of the groundwater protection legislation, radioactive substances are considered 'hazardous substances'. Materials or waste that are 'out-of-scope' of the radioactive substances regulations, are not defined as radioactive substances and should be treated as conventional materials or directive waste in accordance with their non-radioactive properties.

5.2.4 Radioactive waste may contain non-radioactive substances or groups of substances that are considered 'hazardous substances' because they are toxic, persistent and liable to bioaccumulate or because they give rise to an equivalent level of concern. Any other non-radioactive substances or groups of substances in the waste, capable of causing pollution, are considered 'non-hazardous pollutants'.

5.2.5 Groundwater protection legislation requires that:

- inputs of hazardous substances to groundwater are prevented; and
- inputs of non-hazardous pollutants are limited so as to ensure that pollution of groundwater does not occur.

5.2.6 Inputs of radioactive substances to groundwater should be considered in terms of the radiation dose which might be received by people and non-human organisms through the groundwater pathway and any subsequent secondary pathways (Defra, 2010b; SEPA, 2014). It is recognised that absolute and indefinite containment of

[2] Relevant national guidance for England and Wales can be found at Defra (2010b) and EA (2017a), and for Scotland at SEPA (2014) and SEPA (2017a).

pollutants within a disposal facility will not be achievable and it may not be technically feasible to stop all inputs.

Groundwater regulation in England and Wales

5.2.7 The requirements of the Groundwater Directive 2006 (EC, 2006) must 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 (Defra, 2010b).

5.2.8 In England and Wales, inputs to groundwater containing radioactive substances that are 'out-of-scope' of the relevant radioactive substances legislation are also considered to be of a "quantity and concentration so small as to obviate any present or future danger of deterioration in the quality of the receiving groundwater". Such an input is therefore not a groundwater activity under Schedule 22 to EPR 2016, based on its radioactive properties. However, the same inputs could still contain pollutants that constitute a groundwater activity based on the non-radioactive properties of the pollutants.

5.2.9 For radioactive substances that are 'in scope' of the relevant radioactive substances regulations, consideration will be given to whether "all necessary and reasonable measures to avoid the entry of hazardous substances into groundwater have been taken" (Defra, 2010b). In determining which measures are 'reasonable', the principle of optimisation should be observed such that radiation exposures to people through inputs to groundwater are ALARA, taking into account economic and social factors. The dose constraints (during the period of regulation) and risk guidance level (applicable after release from regulation) act as an upper bound on optimisation and ensure a high level of protection for any person potentially exposed to radioactive substances, whether through the groundwater pathway or any other pathway. There is no lower level of dose below which further optimisation is not required.

5.2.10 Determination of whether the prevent and limit requirements of the groundwater protection legislation are met in the case of non-radioactive substances associated with radioactive waste should be undertaken using the normal approaches and methods adopted for conventional pollutants, as described in EA 2017a. The other environmental objectives for groundwater set out in Article 4(1)(b) of the Water Framework Directive such as preventing deterioration, good status and trends, and for protected areas in Article 4(1)(c), must also be met. Compliance with the prevent and limit requirements outlined above should enable these objectives to be achieved.

5.2.11 When identifying options for the on-site disposal of radioactive waste, consideration should be given to the relevant position statements set out in EA 2017a which aim to protect the most sensitive groundwater locations. It is possible that in some cases the controls necessary to meet the requirements for protection of groundwater from non-radiological hazards may be more restrictive than those necessary to limit the radiological hazards. In these instances we would expect control measures to be put in place that are no less stringent than would be required for the equivalent non-radioactive waste to ensure the protection of groundwater. However where, despite consideration of all reasonable mitigation measures, this has the potential to lead to undesirable outcomes, such as greater overall risk to people (including workers, for example from greater processing and treatment of radioactive waste) or grossly disproportionate costs to the benefits gained, then a proportionate, risk-based approach should be taken across the requirements as they apply to both radioactive and non-radioactive substances.

5.2.12 Proposals for on-site disposal of radioactive waste should be individually assessed to determine whether any potential input to groundwater is direct or indirect, having regard to the guidance included in EA 2017a. The Water Framework Directive prohibits the direct discharge of pollutants into groundwater and this is transposed in the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. We may permit certain direct inputs for a number of specific activities; these are set out in paragraph 8 of Schedule 22 to EPR 2016.

Groundwater regulation in Scotland

5.2.13 The requirements of the Groundwater Directive 2006 (EC, 2006) must 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 Scotland by SEPA (SEPA, 2014).

5.2.14 In Scotland, the input of hazardous substances to groundwater should be controlled so that they do not pose a risk of deterioration and the input of non-hazardous substances should be limited so that they do not cause pollution.

5.2.15 Radioactive material and radioactive waste[3] are considered to be hazardous pollutants in groundwater. Environmental impact is assessed by comparing the potential radiation exposure people may receive via all pathways from all radioactive substances in a source (or group of sources) against the relevant risk and dose guidance levels.

5.2.16 Assessment of the impact of non-radioactive substances associated with radioactive waste should be undertaken using the normal approaches and methods adopted for conventional pollutants, as described in SEPA 2014. This describes an approach based on compliance with pollutant-specific groundwater quality standards. Inputs above these standards can be permitted by SEPA if they meet a relevant exemption from the measures required to prevent or limit inputs to groundwater set out in EC 2006.

5.2.17 Ground can often be contaminated by both radioactive and non-radioactive substances. Where the groundwater standards for both the radioactive and non-radioactive contamination are being breached, decisions about remedial action and the applicability of an exemption should take account of the joint overall impact from all the contaminants present in the ground in a holistic manner.

5.3 Protection of the water environment

5.3.1 In England and Wales, the Water Resources Act 1991 and EPR 2016 and in Scotland the Water Environment (Controlled Activities) (Scotland) Regulations 2011 implement provisions of the Water Framework Directive to regulate activities, so that the wider water environment is protected from adverse effects of:

- water abstraction
- water impoundment
- water course engineering
- discharges to surface waters

[3] As defined in the Radioactive Substances Act 1993. Soon to be repealed and replaced by the Environmental Authorisation (Scotland) Regulations 2018

5.3.2 The operator should ensure that they comply with the relevant provisions when embarking upon any activity covered by this legislation.

5.4 Directive waste

5.4.1 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 that it applies to is known as 'directive waste'. The Waste Framework Directive concerns the collection, transport, recovery and disposal of directive waste and includes a common definition of directive waste. This directive requires all member states to take the necessary measures to ensure directive waste is recovered or disposed of without endangering human health or causing harm to the environment. Defra and SEPA have published guidance on the legal definition of directive waste and its application (Defra, 2012; SEPA, 2006 & 2007).

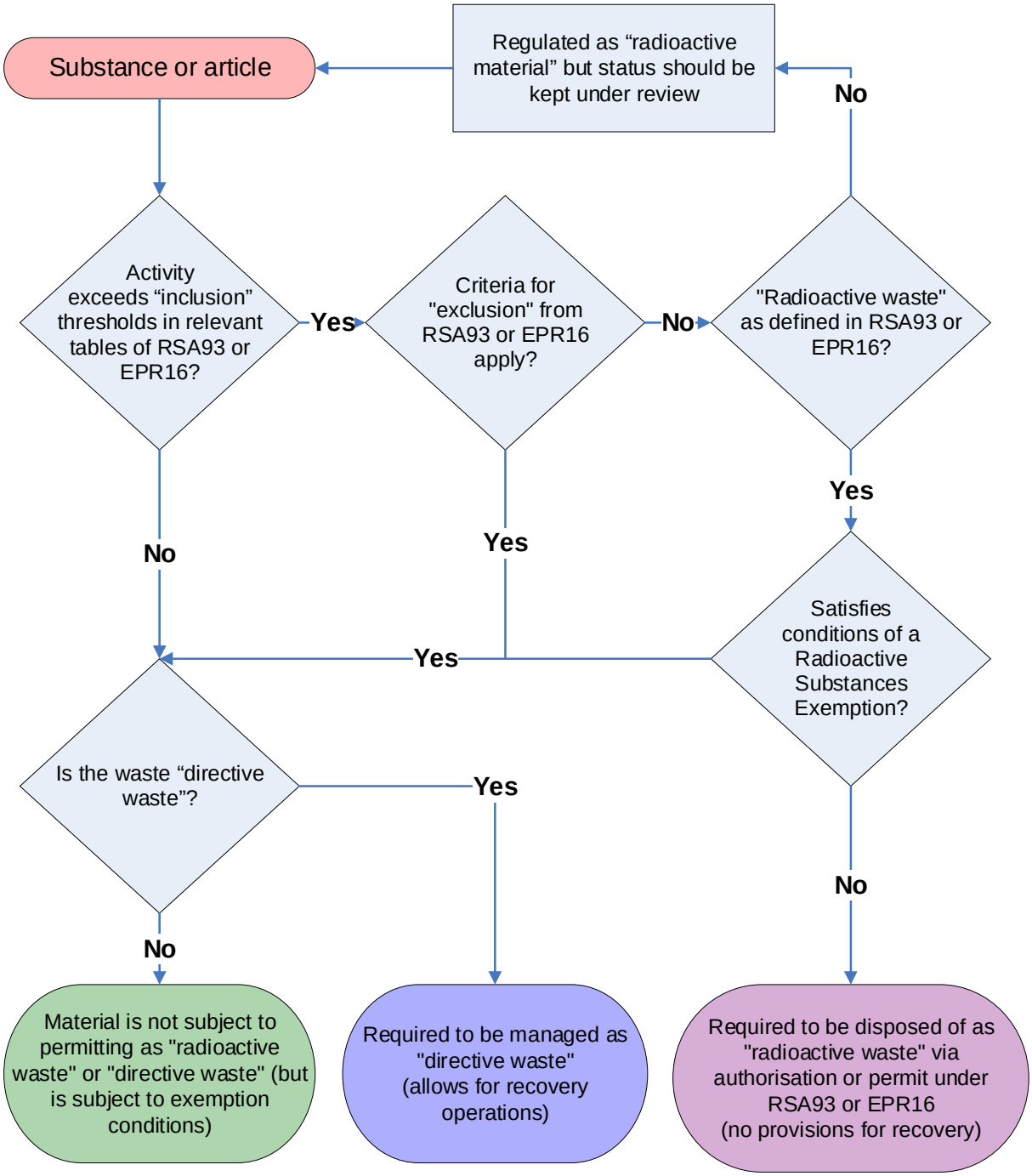
5.4.2 The recovery and disposal of directive waste requires a permit under EU legislation. However, there are exemptions provided for certain activities, provided that specified general rules are followed and the operation is registered with the relevant registration authority. The Waste Framework Directive is enacted principally in England and Wales by EPR 2016 and in Scotland by the Environment Act 1995, the Landfill (Scotland) Regulations 2003 and the Waste Management Licensing (Scotland) Regulations 2011. Disposal of directive waste into or onto land comes under the Landfill Directive (1999/31/EC; EC, 1999) which sets out the minimum standards for engineering, monitoring, operation, closure and aftercare requirements. Defra has published environmental permitting guidance on how to comply with the Landfill Directive (Defra, 2010a) and landfill sector technical guidance is also available in England (EA, 2014) and Scotland (SEPA, 2017a).

5.4.3 Our guidance in this document applies only to radioactive contamination and radioactive waste. While our requirements include consideration of the physical and chemical hazardous properties associated with radioactive contamination and waste (Annex A, Requirement R15) they do not extend to any hazards related to the non-radioactive contaminants and directive wastes on-site. However, we would strongly encourage operators to consider an integrated approach to radioactive and directive waste management, especially during final decommissioning of a site. The WMP could be a useful instrument to draw these different elements together into an integrated whole.

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

5.4.5 Figure 7 provides an overview of the relationship between radioactive and directive waste.

Figure 7 Relationship between 'radioactive waste' and 'directive waste' management



Key:

RSA93 = Radioactive Substances Act 1993 [soon to be repealed and replaced by the Environmental Authorisation (Scotland) Regulations 2018]

EPR16 = Environmental Permitting (England & Wales) Regulations 2016

Note: This figure is intended only to be illustrative, for a definition of radioactive waste refer to relevant legislation and government guidance (Defra et al, 2011)

5.5 Article 37

5.5.1 Article 37 of the Euratom Treaty (European Atomic Energy Community, 1957) requires that each Member State of Euratom submits information to the European Commission about any plan for the disposal of radioactive waste. This is to enable the Commission to give its opinion on whether implementation of the plan is liable to result in radiological contamination (significant from the point of view of health) in another Member State.

5.5.2 Relevant operations for consideration include 'the emplacement of radioactive waste above or under the ground without the intention of retrieval'. Therefore, if the WMP for a nuclear site contains a proposal to dispose of radioactive waste on-site (including leaving radioactive waste in situ), the requirements of Article 37 must be considered. We expect that operators will need to make a submission in most cases (unless it can be clearly demonstrated that Article 37 does not apply in a particular case). Compliance with Article 37 is a UK government responsibility and the lead department is the Department for Business, Energy and Industrial Strategy (BEIS). BEIS should be consulted should there be any doubt about the application of Article 37. While we can receive and determine an application, the permit for any such disposal must not come into effect until we receive a positive decision from the European Commission.

5.5.3 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 submission for the proposed associated radioactive waste disposal would not be needed.

5.5.4 If the WMP for the site is revised, such that the radiological consequences for 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 the operator should update the Article 37 submission and any permit variation needed to authorise the disposal must await a positive decision before taking effect.

5.6 ONR regulation of safety and security on nuclear sites

5.6.1 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.

5.6.2 On a nuclear licensed site, the prevention of contamination of ground and groundwater by radioactive substances, and the management of such contamination should it occur, is subject to some overlap in the regulatory duties and powers of ONR and the relevant environment agency. In developing plans for the management of contaminated ground and/or groundwater, operators should therefore refer to the jointly published 'Regulatory Expectations for Successful Land Quality Management at Nuclear Licensed Sites' (ONR, NRW, SEPA & EA 2014).

5.6.3 The environment agencies and ONR have developed a 'Joint Regulators' Statement of Common Understanding' on the disposal of radioactive waste on nuclear sites by deposit or burial (EA, SEPA, NRW & ONR, 2016). This document is intended to support this guidance by explaining the harmonised approach that the regulators will take in regulating waste management activities on nuclear sites in the final stages of decommissioning.

5.6.4 ONR has provided guidance on nuclear licensed site de-licensing on its website. There is no direct statutory link between release from RSR 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 sets 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 that might otherwise arise. The environment agencies have liaised with ONR in the development of this guidance and will continue to do so during its implementation.

5.6.5 We strongly encourage operators to co-ordinate their plans for release from RSR with arrangements for compliance with their nuclear site licence conditions that relate to land quality management. Implementation of options for the management of radioactive waste and contamination on site should align with the operator's intent to satisfy ONR requirements.

5.7 ONR regulation of the environmental impact of nuclear reactor decommissioning

5.7.1 ONR is responsible for ensuring that the environmental impacts of decommissioning nuclear power stations and nuclear reactors are assessed prior to the commencement of any decommissioning work. This duty is enacted through the Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1999 (EIADR). These regulations implement the Environmental Impact Assessment (EIA) Directives (EC, 1985; EC, 1997; EC, 2003) and are part of the land use planning regulatory system.

5.7.2 Under the EIADR, operators of nuclear sites have to apply for consent to carry out a dismantling or decommissioning project and must submit an environmental statement in support of their application. The environment agencies are statutory consultees under EIADR and have the opportunity to provide comments on the environmental statement and make representations on the application.

5.7.3 The guidance on EIADR (HSE, 2007) recognises the regulation of radioactive waste management undertaken by the environment agencies and that an operator's compliance with the relevant environmental legislation is important in minimising the environmental effects of decommissioning.

5.8 Land-use planning legislation

5.8.1 Proposals for managing and disposing of radioactive waste on a nuclear site may require planning permission under the Town and Country Planning Act 1990 in England and Wales, or the Town and Country Planning (Scotland) Act 1997 in Scotland. The land-use planning system is separate to and independent of RSR. We consult the relevant local planning authorities on relevant RSR applications, and they consult us on relevant planning applications, but the granting of one is not dependent upon granting of the other.

5.8.2 We strongly encourage the operator to discuss their proposals for decommissioning, clean-up and associated radioactive waste management with their local planning authority as early as practicable.

Annexes

Annex A Principles and Requirements

A1 Introduction

A1.1 Our fundamental protection objective is to ensure that a nuclear site is brought to a condition at which it can be released from RSR, 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.

A1.2 In this Annex we set out five principles that are intended to guide operators on how the decommissioning and clean-up of nuclear sites should achieve the fundamental protection objective stated above. We have chosen the fundamental protection objective and the principles to reflect our primary aims and as far as possible to be of an enduring nature.

A1.3 We also set out fifteen individual requirements that form the key obligations of this guidance. The requirements are deliberately more specific than the principles, to enable operators to provide evidence that they have been met.

A1.4 We expect an operator's case for the release of a site from RSR to demonstrate:

- **either** that no radiological hazard remains on a site; **or**
- that **all** the requirements set out in this guidance are met.

A1.5 We expect the requirements to be met in a manner proportionate to the radiological, and any associated non-radiological, hazards that the operator intends to reduce or remove, or to leave on or adjacent to their site.

A1.6 The requirements 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.

A1.7 Our requirements are set out below in two sub-sections: management requirements (section A3) and technical requirements (section A4).

A2 Principles

Principle 1 Level of protection against radiological hazards

A2.1 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 against the radiological hazards to people and the environment, to the national standards applicable at the time when relevant actions are taken.

A2.2 This principle is consistent with the concept of intergenerational equity, including the availability of a clean environment to future generations. We will judge what constitutes a clean environment according to our present-day standards.

A2.3 Radiological risks may not be confined within national borders and may remain for a long time. Therefore operators should ensure safety standards are upheld both locally and further afield, and that where future generations could be affected, they are afforded the same level of protection as that applied at the time of surrender of a permit.

A2.4 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 species of non-human organisms 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 that population.

A2.5 Where a standard of protection is numerical, operators must carry out quantitative assessments to show conformity with it.

A2.6 Standards are continually being reviewed and 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 guidance.

A2.7 The International Committee on Radiological Protection (ICRP) provides recommendations and guidance on radiation protection (ICRP, 2007). The ICRP principle of optimisation 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 dose constraint during the period of authorisation and a risk guidance level (a reference level, see Requirement R10), rather than a risk constraint, after release from regulation.

A2.8 The environment agencies regard the advice from the International Atomic Energy Agency (IAEA) as a statement of good practice. Principle 1 of this guidance 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) “People and the environment, present and future, must be protected against radiation risks.”

Principle 2 Optimisation (as low as reasonably achievable)

A2.9 **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.**

A2.10 The principle of optimisation requires that exposures to people, from authorised activities involving ionising radiation, are kept as low as reasonably achievable, taking account of economic and social factors. Optimisation applies to radiological exposures to people. Other living organisms should also be protected from radiological hazards but there is no statutory optimisation requirement. People and other living organisms should also be protected from non-radiological hazards, in compliance with applicable legislation and taking relevant guidance into account.

A2.11 For decommissioning sites, the optimisation of exposures to people is complex because it must also factor in several competing exposure risks. These exposure risks include those to the public and workers that might impact different geographically dispersed groups and occur on very different time scales.

A2.12 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. The terms Best Available Techniques (in England and Wales) and Best Practicable Means (in Scotland) refer to the option that is identified as the outcome of the optimisation process.

A2.13 Optimisation decisions balance the detriment or harm associated with the radiological risk, together with other benefits and detriments arising from the option under consideration, with the resources available for protecting people and the environment. Optimisation decisions are constrained by the circumstances prevailing at the time, but should consider benefits and detriments at the time the decisions are taken and in the future, to the extent possible. Optimisation needs to be viewed as part of a bigger picture, recognising that there will be competing claims for limited resources, 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. Principle 1 aims to ensure that the radiological risk is at a suitably low level.

Principle 3 Level of protection against non-radiological hazards

A2.14 **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 radioactive substances, to a level consistent with that provided by the national standards applicable at the time when relevant actions are taken.**

A2.15 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 a range of national assessment approaches and standards for non-radiological hazards (EA, 2017b; SEPA, 2017b; NRW, 2014 & 2017). This principle does not require these standards necessarily to be applied in relation to radioactive substances, 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 for non-radioactive hazards were applied.

Principle 4 Reliance on human action

A2.16 **When the site is ready to be released from regulation there shall be no requirement for human action in order to protect people and the environment. The site should be brought to a condition at which it can eventually be released from radioactive substances regulation, in a manner which places a progressively reducing reliance on human action to protect people and the environment against radiological and any associated non-radiological hazards.**

A2.17 Protection of the public and the environment may be provided by controls that rely on people or through passive measures, i.e. measures that do not depend on human intervention. We envisage that, in general, sites will move from decommissioning, through a period of control that relies on people, to the point where it is ready to be released from regulation, after which only passive measures, such as engineered or geological barriers are relied upon. The SWESC should not

place any reliance on controls that require future human actions after release from RSR.

Principle 5 Openness and inclusivity

A2.18 **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.**

A2.19 The relevant environment agency shall, where appropriate, consult interested parties and the public about regulatory decisions in an open and inclusive way.

A2.20 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
- provide an audit trail of regulatory decision-making

A2.21 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.

A2.22 Operators and other organisations should also work in a way that is consistent with this principle and our approach, to ensure a fully open and inclusive process.

A3 Management Requirements

A3.1 The management requirements specified in R1 to R6 concern the planning, execution and recording of decommissioning and clean-up activities at nuclear sites. The requirements aim to ensure that attention is given to the management of decommissioning and clean-up wastes throughout the lifetime of a site and in a way that engages with regulators and other stakeholders.

Requirement R1. Optimisation of waste management options

A3.2 **Operators should use a proportionate process to select options, for managing radioactive waste arising from decommissioning and clean-up, that are optimised. This process shall 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) taking account of economic and social factors. The process should also consider the need to manage radiological risks to other living organisms and to manage the non-radiological hazards associated with radioactive waste.**

A3.3 We expect operators to employ a systematic process to select an optimised waste management option, or range of options, for each of the radioactive wastes that exist, or are expected to arise over the lifetime of the site. Considerations of when and how to clean-up any radioactive contamination should also be integrated into the wider optimisation process for the radioactive wastes. The chosen option, or options, for the later stages of decommissioning must enable the site to be released from RSR in accordance with the technical requirements set out in section A4. This options assessment process is an essential part of ensuring that operator's overall plans for decommissioning and clean-up are optimised. For additional guidance on optimisation, see EA 2010a and SEPA 2012.

A3.4 Operators should consider the non-radioactive properties associated with radioactive waste as part of the optimisation process, and should address radioactive and non-radioactive hazards in an integrated manner when assessing radioactive waste management options.

A3.5 The optimisation process in the later stages of decommissioning has to work within the constraints of past decisions regarding design, construction and operation of nuclear sites. Developers of a new nuclear facility should ensure their plans take account of decommissioning, clean-up and waste management at all stages of the facility's lifecycle.

A3.6 Optimisation must 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 through the effective application of the waste management hierarchy
- using resources effectively, efficiently and economically
- using best practice
- public acceptance
- establishing an acceptable SWESC

A3.7 To identify an optimised solution, operators should carry out options assessments where there are choices to be made between sufficiently different alternatives. Operators should present the results to us and make them publicly available. The assessments will inform operators' decisions. We will not agree to an approach that focusses principally on meeting the numerical dose and risk criteria and does not address optimisation.

A3.8 In these assessments, operators should consider all relevant factors in relation to the generation, treatment, packaging, storage, retrieval, and disposal of radioactive waste, including but not limited to:

- the extent and manner of decommissioning and clean-up
- the timing and sequencing of decommissioning and clean-up activities
- the resulting management requirements for radioactive and directive wastes
- whether wastes are to be disposed of on-site or consigned for disposal elsewhere

A3.9 In addition to the general considerations identified above, operators should also have regard to issues such as, but not limited to:

- the options and associated timescales to clean-up ground and/or groundwater contaminated by radioactive substances on or adjacent to a site
- the availability of suitable disposal facilities for radioactive waste retrieved or created
- the risk and cost of retrieving or creating the radioactive waste and putting it into a form suitable for transport and disposal
- the risk and cost of transport and disposal themselves
- radiation exposure and other sources of risk associated with wastes

A3.10 Operators must assess the impacts of different options, both local to and remote from their site, For options involving disposal to authorised off-site facilities, we do not require an assessment of the contribution that disposal will make to the radiological risks from those facilities. Such facilities will already have been subject to optimisation and environmental safety assessment, and will have established appropriate waste acceptance criteria. However, other impacts associated with use of an off-site disposal option can and should be quantified, for example doses to the workforce from handling waste for off-site disposal.

A3.11 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 operators. 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 information on the as-built design and the condition of the plant may be outdated or limited.

A3.12 In 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 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, should 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 different way to that originally envisaged. Operators' decision-making in relation to optimisation of waste management options only comes to an end when all planned work involving radioactive substances on the site is complete.

Collective dose

A3.13 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 aiding decisions 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. Public Health England (PHE) (formerly the Health Protection Agency (HPA)) states (HPA, 2009) that it concurs with this view for assessments of solid waste disposal.

A3.14 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. ICRP recommends that, in broad terms, the concept of collective dose is retained but within the context of a 'dose matrix'. However, 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 that there is little to be gained from the 'dose matrix' approach for times far into the future.

A3.15 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 completion of all planned

decommissioning and clean-up work 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 R2. Waste management plan

A3.16 **Operators should prepare a waste management plan (WMP) to manage the programme of disposals of radioactive waste from their nuclear site, and implement the plan to achieve the site reference state.**

A3.17 Operators should develop and maintain a WMP (see glossary for definition), as part of their wider decommissioning plans. The WMP is closely linked to the SWESC (see Requirement R7) and operators should develop them together, and maintain consistency between them.

A3.18 We expect the WMP and SWESC to be 'live' products which should be sufficiently comprehensive for each stage of the lifecycle of a nuclear site.

A3.19 As a minimum the WMP should:

- demonstrate that waste management has been optimised (R1)
- identify all current and prospective disposals of radioactive waste
- demonstrate that any proposed on-site disposals of radioactive waste are optimised (R13)
- demonstrate that the disposals are consistent with the evidence and arguments presented in the SWESC

A3.20 In addition we encourage operators in their WMPs to take an integrated approach to the management of both radioactive waste and directive waste over the lifetime of the facility.

A3.21 The WMP should cover all forms of radioactive waste, including:

- existing waste
- waste anticipated to arise (including any waste generated from clean-up of ground and/or groundwater contaminated by radioactive substances)
- waste in situ

A3.22 The WMP should cover all forms of radioactive waste disposal such as:

- disposal by transfer off-site
- disposal by emplacement on-site, such as into an on-site radioactive waste disposal facility or for a purpose, such as void filling
- disposal by deliberately leaving radioactive waste in situ
- disposal of liquid and gaseous radioactive waste by discharge to the local environment

A3.23 Operators must apply for, and be granted, authorisation under the permit before making any form of radioactive waste disposal. A WMP and a SWESC, that are comprehensive, credible and mutually consistent, are prerequisites for granting such authorisation.

A3.24 We provide further guidance on the purpose and content of a WMP in Section 3 of the main text.

Requirement R3. Early engagement

A3.25 **Operators should engage as early as possible with the relevant environment agency.**

A3.26 We consider that early discussions will provide significant benefits for both operators and the environment agencies. Although we cannot provide regulatory certainty before formal applications are determined, early discussions 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 give early advice on possible environmental concerns.

A3.27 Early discussions with us could also offer benefits to operators in their discussions with land-use planning authorities. The environment agencies are consultees under the planning regime and therefore knowledge of, and confidence in, operators' plans will assist us in making our responses to the planning authorities (also see Requirement R4).

A3.28 Early engagement would encourage open discussion of operators' proposals and the regulator's views with stakeholders such as local communities, other interested parties and the public, in advance of any formal consultation required by the application process.

Requirement R4. Engagement with local communities and others

A3.29 **Operators should engage with local communities, ONR, the planning authority, other interested parties and the public on their developing WMP and SWESC.**

A3.30 Generally, we expect operators to engage widely in discussion of their plans to achieve the site reference state and their developing WMP and SWESC. The planning authority and local communities are likely to have an important role in any such discussions. Where sites are located immediately adjacent to another nuclear site, we expect operators to engage with each other in the development of their WMP and SWESC.

Requirement R5. Environmental safety culture and management system

A3.31 **Operators should maintain a positive environmental safety culture appropriate to the activities being undertaken on-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 R6); and (f) quality management.**

A3.32 We expect operators to maintain a positive environmental safety culture, such as appropriate individual and collective attitudes and behaviours, and require their suppliers to do the same. This culture needs to be reflected in and reinforced by the operators' management systems.

A3.33 During the period of RSR, the permit will specify the requirement for operators to develop and maintain an effective management system. This management system should be progressively adapted throughout the full lifecycle of the nuclear site, to ensure suitable corporate governance of the organisation until release from RSR. Operators should demonstrate to us that their 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, knowledge and records management.

A3.34 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.

A3.35 Throughout the permit lifetime, operators 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 release from regulation, 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 purpose.

A3.36 For more detail on the factors that the environment agencies will consider in our evaluation of operators' management systems, see the NS-GRA (EA et al., 2009) and the Environment Agency's guidance on management arrangements at nuclear sites (EA, 2010b).

Requirement R6. Preservation of knowledge and records at the time of release from radioactive substances regulation

A3.37 **Operators shall manage and retain adequate records of their site's journey to completion of all planned work involving radioactive substances and also, where necessary, provide adequate records of the controls applied up to the site reference state being achieved along with the required validation monitoring data. Operators 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 the records.**

A3.38 After release from regulation, 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, prior to release from RSR operators should ensure appropriate archiving of records. We expect operators to take all reasonable steps to ensure that such records will be preserved, and consider making appropriate use of the national nuclear archive.

A3.39 Before we release a site from RSR, we will expect operators to demonstrate that arrangements have been put in place for the transfer, long-term safe-keeping and management of the records of the site by a suitable organisation. We will also expect operators to show that these arrangements can be and are being implemented.

A3.40 Relevant records 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, and areas of contamination on-site. These records will encompass, but will not necessarily be limited to:

- the radiological hazards presented by the radioactive waste and contamination including: radionuclide inventory; the chemical and physical form of the radioactive substances; and the specific manner of disposal of the waste
- the non-radiological hazards presented by the radioactive substances, 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 inadvertent human intrusion
- any uncertainties that may be of significance in interpreting and using the data recorded

A3.41 Operators should provide the knowledge and records in a form that can be interpreted by technical specialists who do not have site-specific knowledge. Operators should also provide summary information that can be interpreted by lay persons so that they can understand whether and when to involve technical specialists.

A3.42 In the preparation of records operators should take account of relevant standards, guidance and codes of practice that are applicable at the time of release from regulation, to maximise the probability that these records and the means of interpreting them will continue to be preserved into the long-term future.

A3.43 There should be no requirement for reliance on knowledge held by individuals. All required knowledge should be captured within the record set.

A4 Technical Requirements

A4.1 The following technical requirements are focused on managing the hazards from ionising radiation from radioactive waste management to ensure that people and the environment are protected. Interfaces with other regulatory regimes are highlighted, and where relevant, references are given. Within this guidance we have provided high level references only; operators should ensure that where activities fall outside of the RSR regime they use the appropriate guidance and have the required authorisations.

Requirement R7. Site-Wide Environmental Safety Case

A4.2 **Operators should maintain a site-wide environmental safety case (SWESC) to demonstrate that people and the environment will be adequately protected from ionising radiation and any associated non-radiological hazards, both before and after their site is released from radioactive substances regulation.**

A4.3 The SWESC is a set of claims concerning the environmental safety of the nuclear site, substantiated by a structured collection of arguments and evidence (see glossary). It should address the present condition and all envisaged future conditions 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 radioactive substances remaining on and adjacent to the site including any ground or groundwater affected by contamination. It should demonstrate that people and the environment will be protected from the radiological hazard and any non-radiological hazards associated with both radioactive waste and contamination. 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 WMP (see Requirement R2) and operators should develop their SWESC and the WMP together, and maintain consistency between them.

A4.4 Operators should maintain, and provide to the relevant environment agency when required, a SWESC that demonstrates conformity with the principles and requirements set out in this guidance. The SWESC should be technically sound, comprehensive and robust, but also proportionate to the magnitude of the radiological and any associated non-radiological hazards.

A4.5 The SWESC should also describe the condition of the site at the time when all planned work involving radioactive substances has ceased. That condition may, or may not, be the same as the site reference state. If it is not the same, that is, if operators have proposed a period of control for the purpose of radiological protection, the SWESC should demonstrate that the site reference state will be achieved from that condition through natural processes including radioactive decay, dilution and dispersion, within the proposed period of time. During this proposed period the site will remain under RSR with appropriate controls. The SWESC should describe these controls and substantiate that they are sufficient and practicable for protecting people from the ionising radiation hazards and any associated non-radiological hazards, and that the controls will endure for the proposed period. It is unlikely that the environment agencies would accept a proposal for a period of control lasting longer than 300 years, because of the major social changes that may take place over long periods of time.

A4.6 The SWESC should specify the nature and duration of the validation monitoring that is needed after all planned work involving radioactive substances is complete. The purpose of validation monitoring is to confirm that the condition and behaviour of the site is in accordance with the assumptions of the SWESC. The relevant environment agency will only release a site from RSR after operators have completed an appropriate validation monitoring programme that demonstrates that the site will meet our standards for protection of people and the environment.

A4.7 In addition, the SWESC should demonstrate that members of the public and the environment will be adequately protected while work involving radioactive substances is still being done. 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.

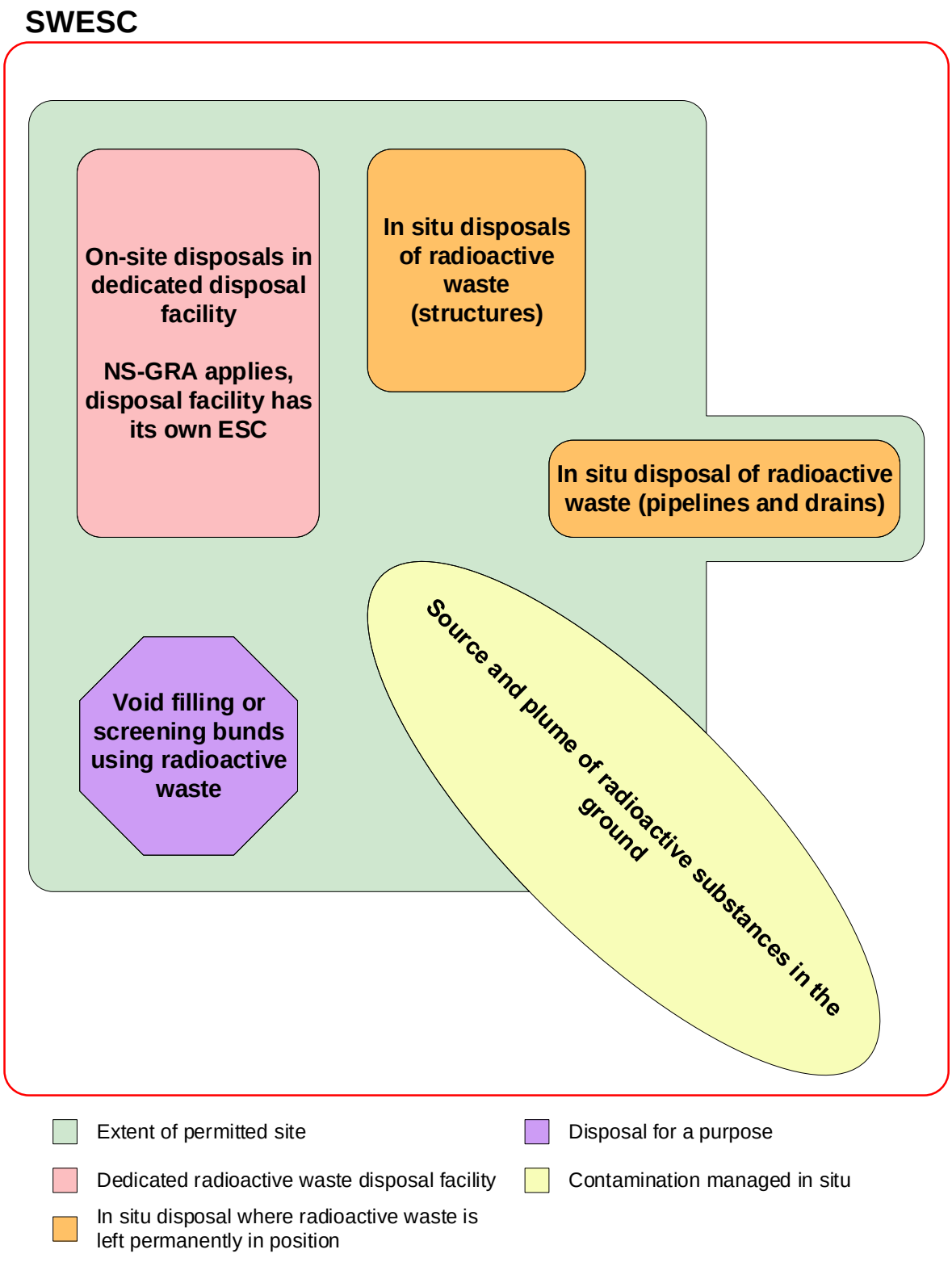
A4.8 The SWESC need not be a stand-alone document, but can make reference to any documentation that provides evidence to support the case. However, there needs at least to be a top level, or signposting, document that provides a focus for the SWESC. We provide further advice on the structure and content of the SWESC in Section 4 of the main text.

A4.9 The SWESC must support any application from the operator to make an on-site disposal of radioactive waste or to seek release from RSR.

A4.10 Figure 4 (see Section 2 of main report) provides a timeline showing the progressive development of the SWESC. It also shows when the dose constraint under Requirement R9 applies and when the risk guidance level under Requirements R10 and R12, and the dose guidance level under Requirements R11 and R12 apply.

A4.11 We 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 this guidance we distinguish between a disposal facility constructed solely for the purpose of disposal of radioactive waste and other types of disposal such as disposal in situ and disposal for a purpose. A constructed disposal facility must meet the requirements of the NS-GRA and will have its own environmental safety case (ESC), which will define the waste acceptance criteria for the facility. The ESC for the disposal facility will provide a component of the wider SWESC for the site as a whole. Figure A1 illustrates the relationship between the SWESC and the NS-GRA for a range of possible disposals options.

Figure A1 Relationship between SWESC and the NS-GRA



Note: This schematic shows the potential scope of the SWESC at the end of all planned work involving radioactive substances. Before this time the SWESC should also include any liquid or gaseous discharges.

Requirement R8. Site characterisation and monitoring

A4.12 **Operators should carry out a programme of site characterisation and monitoring to provide information needed to support the WMP and SWESC. The programme shall include appropriate validation monitoring to provide technical confirmation that progress towards the site reference state is as expected or to validate that the site reference state has been achieved.**

A4.13 Site characterisation and monitoring should 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. Operators should establish a proportionate approach to site characterisation and monitoring that uses appropriate assessments to guide further investigations, taking into account the nature of operations and former operations on-site.

A4.14 Site characterisation and monitoring should 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
- uncertainties in each of the above

A4.15 The site characterisation programme should also 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, from historic authorised discharges and from any local or remote nuclear accidents.

A4.16 Operators should 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. Operators should also consider features and properties of the site related to the release and transport of radionuclides in the gas phase. 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 release from regulation.

A4.17 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

A4.18 Operators should establish a reasoned and proportionate approach to monitoring their site and any disposals 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 the site is consistent with the SWESC assessments.

A4.19 To provide a baseline for monitoring at later stages, operators should make an early assessment of the monitoring required to support the SWESC. 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. Current useful references to assist in defining the monitoring programme include: guidance on environmental radiological monitoring (EA et al., 2010); guidance on monitoring of landfill leachate, groundwater and surface water (EA, 2003), and the Nuclear Industry Group for Land Quality NICoP for Routine Water Quality Monitoring (NDA, 2015).

A4.20 During the period of RSR, operators must continue 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. Operators should also ensure that changes in the parameters monitored are reflected in the SWESC.

A4.21 The monitoring programme must set out clearly the levels of specific contaminants that will trigger action. It must include an action plan to deal with unexpected levels of contamination and an approach to confirm any apparently positive results to avoid inappropriate action being taken in the event of a false positive observation. The monitoring programme must be reviewed in the event of any changes to decommissioning plans or subsequent change of uses of the site.

A4.22 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 should not depend on monitoring or surveillance after release from RSR.

Requirement R9. Dose constraints during the period of radioactive substances regulation

A4.23 **During the period of radioactive substances regulation the effective dose, from the authorised site, to a representative person shall not exceed a source-related dose constraint and a site-related dose constraint.**

A4.24 The environment agencies are required (Scottish Executive 2000 and EPR 2016) to have regard to the following maximum doses to individual members of the public which may result from a defined source, for use at the planning stage in radiation protection:

- 0.3 mSv per year from any source[4] from which radioactive discharges are made; and

[4] 'Source' in this context means a facility, or group of facilities, which can be optimised as an integral whole in terms of radioactive waste disposals.

- 0.5 mSv per year from the discharges from any single site[5]

A4.25 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. See Annex B for an explanation of the origin of the dose constraints, and their role in fulfilling our duties.

A4.26 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.

A4.27 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 (for example 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.

A4.28 Where sources on a site give rise to a direct radiation impact to members of the public off-site, they must be taken into account in an assessment. In addition any direct radiation exposures due to the migration of radionuclides from the site or via authorised discharges should also be considered (EA et al., 2012.)

A4.29 During the lifetime of the site our regulatory approach regarding current radioactive discharges and disposals will remain the same. We expect operators, in accordance with their permit, to:

- monitor and assess radioactive discharges from the site and levels of radioactivity in the environment (monitoring should be proportionate to the potential hazard) (EA et al., 2010)
- 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)

[5] ‘Site’ in this context encompasses any number of sources with contiguous boundaries at a single location (for example ‘A’ and ‘B’ power stations), irrespective of whether different sources on the site are owned or operated by the same or by different organisations. This use of ‘site’ is specific to the site-related dose constraint and is different from the general interpretation of ‘site’ adopted elsewhere in this document and as explained in section 1.7 of the main text and in the glossary.

- report this information to us

Requirement R10. Risk guidance level after release from radioactive substances regulation

A4.30 **Operators should demonstrate through the SWESC that, after release from radioactive substances regulation, the assessed risk from the remaining radiological hazards to a representative person should be consistent with a risk guidance level of 10^{-6} per year (that is, a risk of death or heritable defect of 1 in a million per year due to exposure to ionising radiation).**

A4.31 The risk guidance level applies to all people after release of a site from RSR. There is no longer a need to make a distinction between members of the public and workers since the authorised 'site' will no longer exist, and there will be no radioactive substances work being undertaken.

A4.32 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 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 those risks, and below which, risks are broadly accepted by society because they are generally regarded as insignificant. See Annex B for an explanation of the origin of the risk guidance level, and its role in fulfilling our duties.

A4.33 The risk guidance level applies to assessed risks from radioactive substances dispersed in the accessible environment (arising from radioactive waste or radioactive contamination) due to the migration or uncovering of radioactive substances 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 radioactive substances and the processes acting on the system.

A4.34 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 must be summed over all situations that could give rise to exposure of the same person to radiation.

A4.35 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 tissue reactions), a risk coefficient of 0.06 per Sv should be used. The risk coefficient is only appropriate when considering risk to populations not individuals. This corresponds to recommendations set out in advice given by PHE in its publication on the disposal of solid radioactive waste (HPA, 2009).

A4.36 For further discussion see the NS-GRA (EA et al., 2009).

Risk assessment

A4.37 Risk assessment aimed at showing consistency with the risk guidance level helps to inform operators 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.

A4.38 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 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 expect operators to demonstrate that the measures chosen are reasonable. Information about the sensitivity of the chosen measures to important parameter values should also be presented.

A4.39 The complexity of a risk assessment should be proportionate to the radiological hazard. For some nuclear sites, operators may be able to avoid using complex models in the risk assessment by making simple conservative assumptions.

A4.40 In setting up a risk assessment, in general operators 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, operators may choose some data and assumptions to be conservative as long as the requirements are still shown to be met.

A4.41 In cases where the hazard remaining on or adjacent to a site warrants a detailed assessment of risks, we 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 representative person 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

A4.42 Our approach to the treatment of uncertainties is summarised in Figure A2.

A4.43 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.

A4.44 After release from regulation, 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.

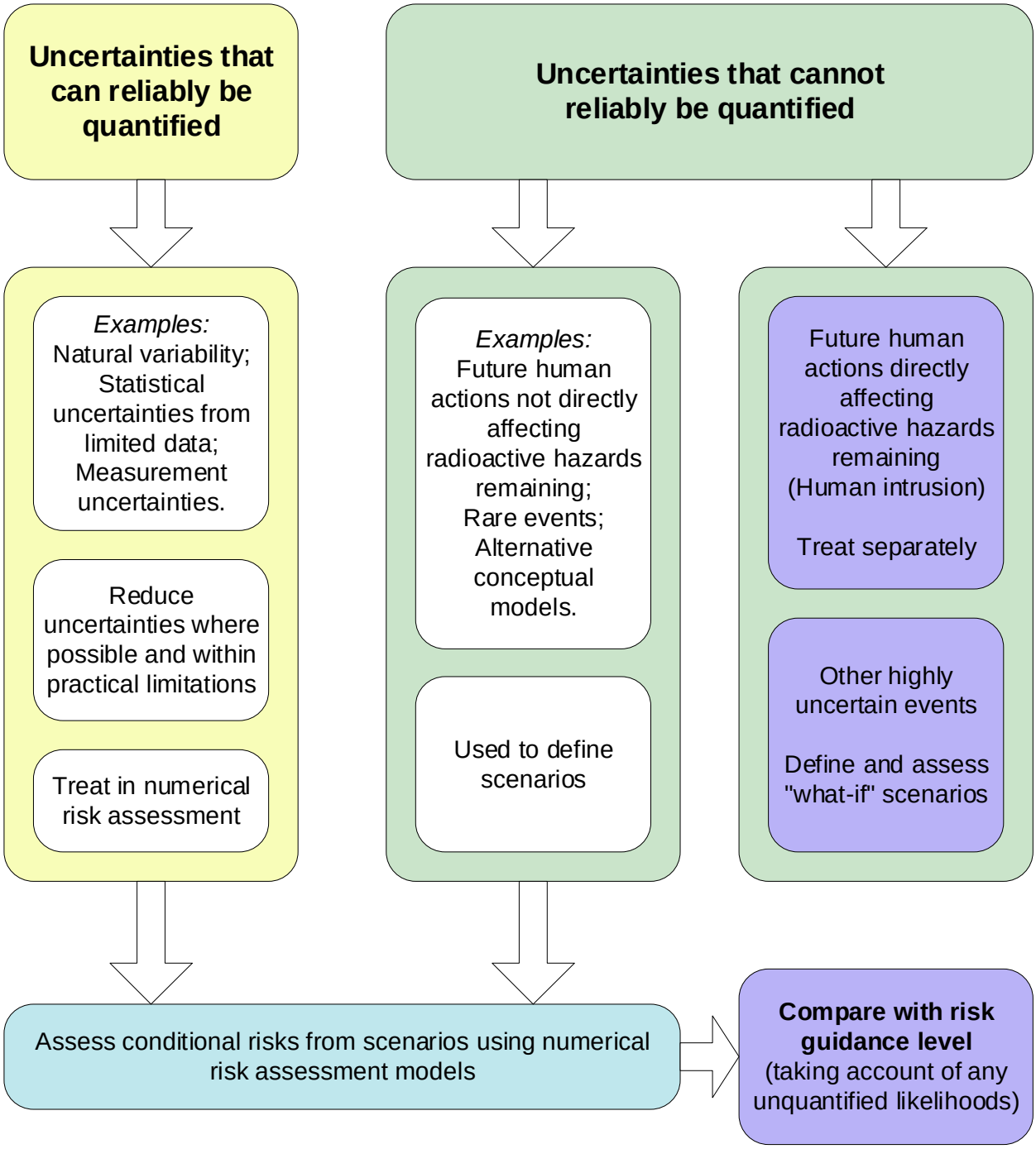
A4.45 An uncertainty cannot reliably be quantified if, for example, it is not possible to acquire relevant data, or if acquiring enough data to evaluate it statistically could only be done at disproportionate cost. Important examples of uncertainties that cannot reliably be quantified (i.e. that are 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.

A4.46 We expect that quantifiable uncertainties will be considered within a numerical risk assessment developed as part of a SWESC (see Section 4.4). Unquantifiable uncertainties should also 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.

A4.47 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.

A4.48 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 we will consider them one by one. Guidance on human actions that affect the SWESC is given under Requirement R11 below, while guidance on natural disruptive processes is given under Requirement R12.

Figure A2 Approach to the treatment of uncertainties



Representative persons

A4.49 Risk assessments should consider different groups of people that have the potential to be exposed in order to define individuals that may receive doses that are representative of the more highly exposed individuals in the population (representative persons) at a given time. There is a range of possible doses that each representative person might receive and, for each dose, an assessed probability of their receiving that dose.

A4.50 Operators should substantiate the choice of representative persons as being reasonable and suited to the particular circumstances. The location and characteristics of the representative persons considered should be based on the assessed releases of radioactive substances and on assumptions about changing environmental conditions. The habits and behaviour assumed for representative persons 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 person 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

A4.51 If two or more separate nuclear sites present significant risks to the same representative persons, consideration should be given to the combined risks to those representative persons. The operators of such separate sites should communicate and cooperate as SWESCs and WMPs are developed. This will require careful co-ordination and forward-thinking, especially in circumstances where operations involving radioactive substances at one site may be ongoing, whilst such operations may have been completed at a nearby site. An unacceptably large total for the assessed risks from different nuclear sites affecting the same representative person 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 operators and ourselves.

Regulators' considerations

A4.52 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 consistency with the risk guidance level has been adequately demonstrated. This judgement will take account of the uncertainties that have been included directly in the main risk assessment as well as uncertainties that have been assessed by what-if scenarios and other sensitivity analysis methods.

A4.53 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.

A4.54 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 will need additional assurance from other information presented in the SWESC to satisfy us that an appropriate level of environmental safety is assured.

A4.55 We will not accept an approach in which the assessed risks from multiple different hazards associated with the same nuclear site are put forward individually in order to show that each hazard, taken alone, presented a risk consistent with the risk guidance level. Nor will we accept an assessment that simply looks to quantify the radiological capacity of the site.

Requirement R11. Inadvertent human intrusion dose guidance level after release from radioactive substances regulation

A4.56 **Operators should assess the potential consequences of inadvertent human intrusion into any local concentrations of radioactive substances on the site after release from radioactive substances regulation. The assessed effective dose to a representative person during and after the assumed intrusion should not exceed a dose guidance level in the range of around 3 millisieverts per year (3 mSv/y) to around 20 millisieverts in total (20 mSv). Values towards the lower end of this range are applicable to prolonged exposures, while values towards the upper end of the range are applicable only to transitory exposures.**

Human intrusion

A4.57 Decisions to dispose of solid radioactive waste in the near-surface environment, or to allow radioactive contamination to remain in the ground, are made on the basis that it remains isolated from people until sufficient time has passed, to allow radioactive decay to reduce the risks to people and the environment to levels that are no longer radiologically significant.

A4.58 An inevitable consequence of such decisions is that, once a site has been released from RSR, local concentrations of radioactive substances remaining there may potentially be disturbed by people before sufficient time has passed. Such disturbance is termed human intrusion. Human intrusion into any radioactive substances remaining on site may be regarded as falling into three classes:

- intrusion with full knowledge of the existence, location, and nature of the radioactive substances
- intrusion without prior knowledge of the radioactive substances
- intrusion with limited knowledge of the existence of past human activity at that location, but without understanding its nature

A4.59 Operators do not need to consider the first of these classes because we take the view that a society that preserves full knowledge of a former nuclear site will be capable itself of exercising proper control over any intrusions into any radioactive substances remaining on that site.

A4.60 Operators should consider the second and third of these classes, which constitute inadvertent human intrusion (see glossary). Examples of the second class would be exploratory drilling for mineral resources, or excavation during future development of the site. An example of the third class would be an archaeological investigation carried out without knowing about the potential for radioactive substances to be present, or understanding the risks it may pose, but recognising that there has been human activity at the site in the past.

A4.61 Inadvertent human intrusion encompasses a wide range of unintended actions that have the potential to disturb radioactive substances remaining on, or adjacent to, a site or to impair barriers intended to protect people and the environment, after

knowledge of the location and nature of the site has been lost, in part or in full, to society.

A4.62 We do not envisage that operators will be able to substantiate that inadvertent human intrusion is unlikely to occur after release from RSR. Operators should therefore assess the potential consequences of inadvertent human intrusion into any local concentrations of radioactive substances on the site against the dose guidance level described below.

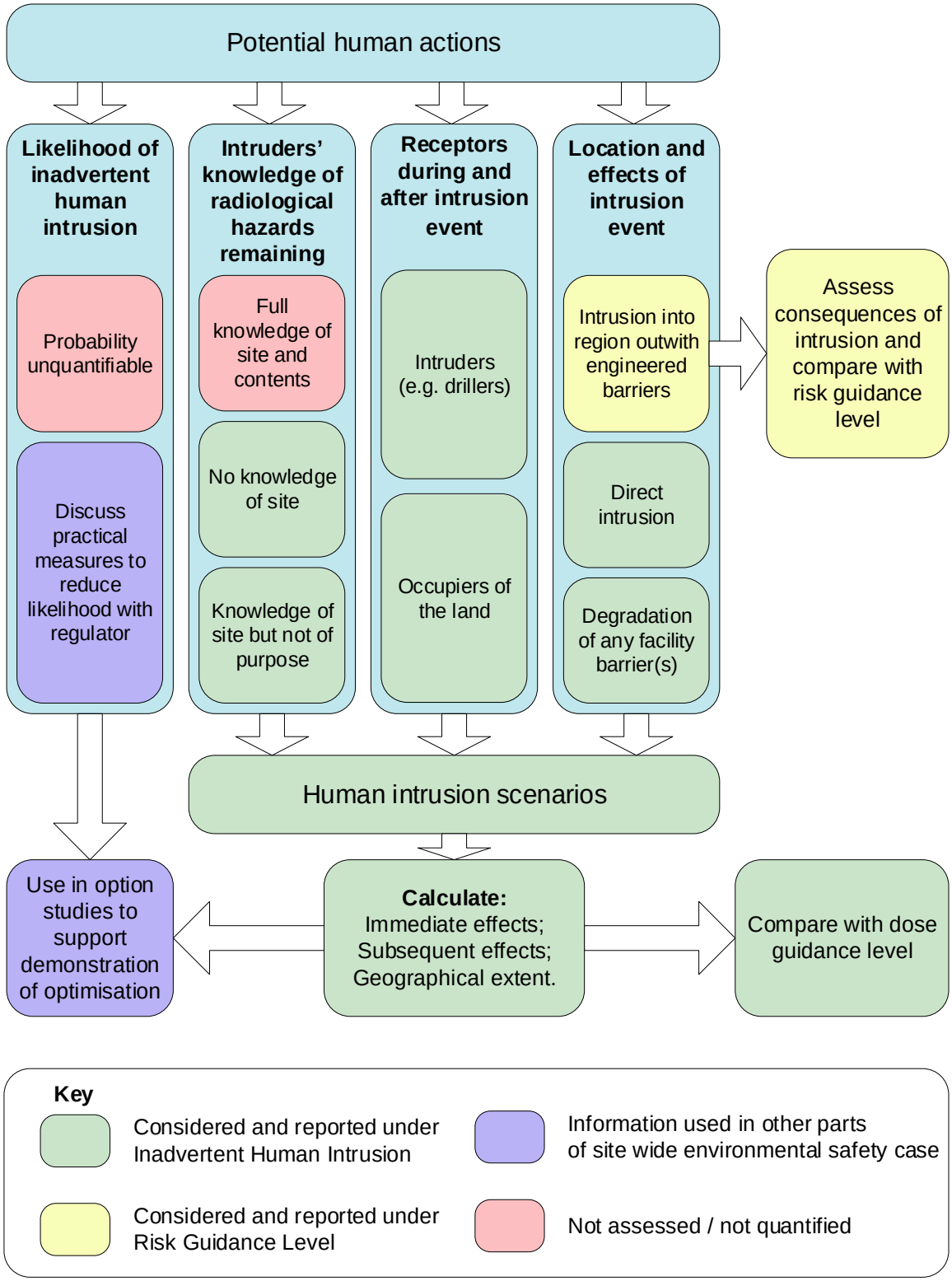
Dose guidance level

A4.63 We use the term *dose guidance level* (see glossary) in this document to describe the assessment standard for inadvertent human intrusion, 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 (ICRP, 1998; IAEA, 2011; IAEA, 2014). The range of around 3 mSv/y to around 20 mSv that we specify for our dose guidance level is the same as that advised by PHE in its publication on the disposal of solid radioactive waste (HPA, 2009). See Annex B for an explanation of the origin of the dose guidance level, and its role in fulfilling our obligations.

A4.64 International and national bodies (ICRP, 1998; HPA, 2009; IAEA, 2011) advise that human actions in the future are unpredictable, so the probability of inadvertent human intrusion into radioactive substances in the near-surface environment cannot be quantified. This means that conventional risk assessments are not possible, and is the reason that the standard against which we require operators to assess inadvertent human intrusion is specified in terms of dose, not risk. We consider, however, that the dose standard we specify is a risk-based standard, but with the probability component necessarily absent. We consider this standard is sufficiently cautious to accommodate the indefinability of the timing, type, extent and probability of inadvertent human intrusion events. Figure A3 illustrates the approach to the treatment of inadvertent human intrusion after release from RSR.

A4.65 The primary purpose of specifying this standard is to prevent people being exposed to unacceptable risks even if the barriers or measures, intended to protect them from radioactive substances, are inadvertently bypassed or impaired. Application of the dose guidance level places upper bounds on such risks, by effectively restricting the activity concentration, of radioactive waste that can be authorised for on-site disposal and radioactive contamination that can be allowed to remain, in the near-surface environment. This restriction on activity concentration provides an additional level of protection of people, against risks of indefinable probability, which cannot be achieved by application of the risk guidance level alone.

Figure A3 Approach to the treatment of human intrusion after release from RSR



Applicability of dose guidance level

A4.66 The dose guidance level applies to all people after release of a site from RSR. There is no longer a need to make a distinction between members of the public and workers since the authorised 'site' will no longer exist, and there will be no radioactive substances work being undertaken.

A4.67 Values towards the lower end of the dose guidance level range are applicable to assessed exposures continuing over a prolonged period; a year or more. Values towards the upper end of the range are only applicable to assessed exposures that are short-term (transitory); where the exposure occurs relative quickly and within a period of less than a year, and there is no exposure in subsequent years. The value of 20 mSv therefore applies to the total transient dose.

A4.68 The dose guidance level applies to the following kinds of inadvertent human intrusion event (see Figure A4(a)):

- intrusion directly into any radioactive waste authorised to be disposed of on a site
- intrusion directly into a defined area of radioactive contamination remaining on or adjacent to a site
- other actions that damage barriers or measures, or that impair their environmental safety functions, such as removing material from the cap of a disposal (barriers that might be affected by these human actions may be engineered, natural, or a combination of both)

A4.69 Figure A4(b) illustrates a number of inadvertent human intrusion scenarios. Exposures could occur both to people carrying out an intrusion activity and to people living or working in the area, through radioactive substances being uncovered, or being brought to the surface by the intrusion activity.

A4.70 Beyond the region where these kinds of event might happen, the dose guidance level does not apply; the standard that applies is the risk guidance level (Requirement R10).

A4.71 If operators propose to invoke natural barriers to provide some environmental safety functions (either alone, or in addition to engineered barriers or measures), we expect operators to discuss their spatial extent with us at the earliest opportunity. It will be a matter of regulatory judgement as to how far from any radioactive waste disposal location it is reasonable to apply the dose guidance level, rather than the risk guidance level. Any benefits claimed, by invoking natural barriers for their environmental safety functions, should be weighed against the undesirability of applying the dose guidance level over a wide area. We maintain a presumption against the invoking of natural barriers for environmental safety functions, unless operators can make a strong case that it is optimal to do so.

A4.72 Figure A4(c) illustrates an example of future human actions to which the dose guidance level does not apply. This figure shows the sinking of a borehole to create a well into a plume of radioactive substances, originating from a disposal of radioactive waste. The waste has been disposed of in a location for which operators are unlikely to be able to make an optimisation case that natural barriers provide environmental safety functions; therefore the risk guidance level applies.

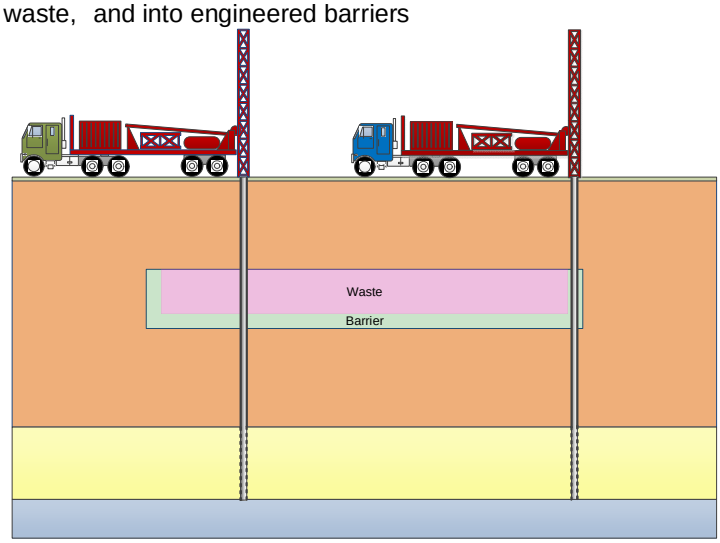
A4.73 Similar considerations apply to radioactive contamination remaining on or adjacent to a site. Operators should assess against the dose guidance level for inadvertent human intrusion into any defined zones of contamination that are demonstrably:

- immobile, whether due to inherent physico-chemical properties or due to measures such as treatment or containment
- limited in areal extent

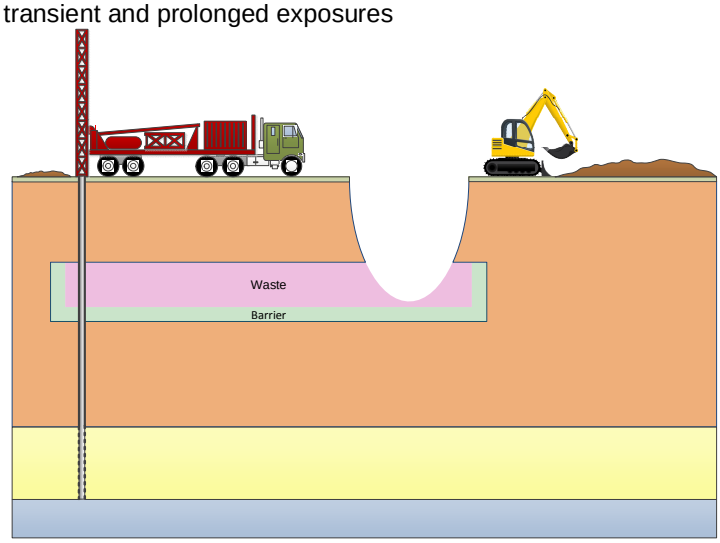
A4.74 All other radioactive contamination (i.e. that is more mobile or extensive in area) remaining on or adjacent to the site should be compared to the risk guidance level (Requirement R10). In reality, both mobility and extent exist on a spectrum, and we expect operators to discuss their plans for managing radioactive contamination with us at the earliest opportunity. It will be a matter of regulatory judgement, for each zone of radioactive contamination, whether to apply the dose guidance level, rather than the risk guidance level.

Figure A4 Inadvertent human intrusion

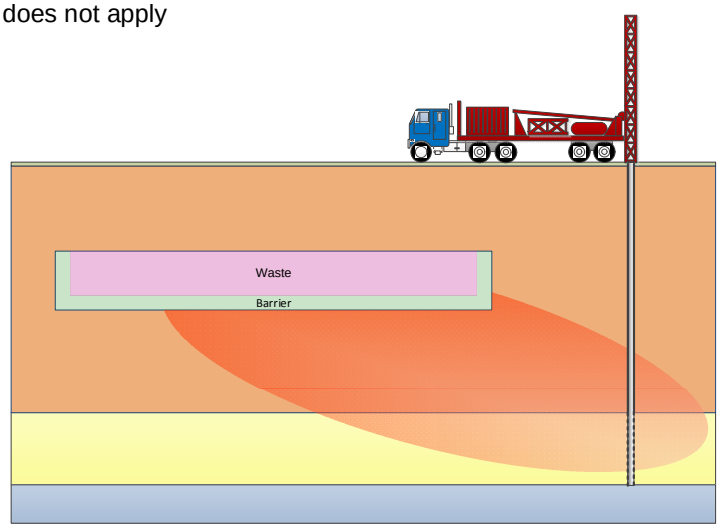
(a) Examples of inadvertent human intrusion: directly into radioactive waste, and into engineered barriers



(b) Examples of Inadvertent human intrusion scenarios leading to transient and prolonged exposures



(c) Example of future human actions to which the dose guidance level does not apply



Assessing the consequences of inadvertent human intrusion on people

A4.75 For each defined location of radioactive waste or contamination remaining after RSR, operators should assess the potential exposures to people that might arise from a range of possible inadvertent human intrusion scenarios. These scenarios should consider exposures that might arise from any gaseous emissions from the radioactive waste or contamination, such as radon. This should not include exposures to naturally occurring radon. Due to the large uncertainties associated with exposures to radon, operators should present these both aggregated with other exposures and individually.

A4.76 Assessments should thoroughly evaluate a range of scenarios that encompasses all likely future intrusion events, including those which could produce the highest potential exposures, both transitory and prolonged. Operators should not use probabilistic arguments to avoid assessing the highest exposures; this would defeat the primary purpose of specifying the dose guidance level (see A4.65).

A4.77 The timing, type and extent of inadvertent human intrusion events into radioactive waste or contamination are so uncertain that they should be explored through one or more ‘what-if’ scenarios, separate from the scenarios representing natural evolution of the site that are considered under Requirement R10.

A4.78 Inadvertent 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 the initial uncovering of radioactive substances, and any subsequent actions such as relocation of the radioactive substances or their removal from the site. The number of people involved in actions associated with the 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 or using the site or its locality after the intrusion should also be assessed. These numbers will be important in assessing radiological effects for optimisation purposes (see A4.82). Operators should substantiate each scenario considered as being reasonable and suited to the particular circumstances.

A4.79 Operators should present assessments of radiation doses to representative individuals both undertaking the intrusion and occupying or using the site or its locality 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.

A4.80 Assessments should also take into account radioactive articles that people might encounter as a result of inadvertent human intrusion. Assessments should consider the possibility of ingestion or inhalation as appropriate. Radioactive articles might also include objects that would be visually identifiable and attractive to people.

A4.81 Assessments should show that dose thresholds for tissue reactions are unlikely to be exceeded as a result of inadvertent human intrusion (ICRP, 2012).

A4.82 Operators should use the results from the inadvertent human intrusion scenarios above as part of optimising on-site disposals and clean-up of contamination. The aim should be to reduce the potential exposures resulting from inadvertent human

intrusion, subject to balancing all the other factors relevant to optimisation. If operators' assessments indicate doses from prolonged exposures (which could occur over many years) close to 3 mSv/y, or doses from transitory exposures close to 20 mSv in total, operators should consider options to reduce the dose and/or the likelihood of receiving the dose. Options might include disposal of radioactive waste by another method, or greater clean-up of local concentrations of contamination, or measures to deter intrusion. Exposures exceeding these levels indicate that disposing of that radioactive waste in the proposed manner and location, or leaving that radioactive contamination on or adjacent to the site, are not acceptable options.

Non-radiological hazards

A4.83 There is no regulatory requirement to assess the disruption by human action of conventional landfills (i.e. for disposal of directive waste that is inert, non-hazardous or hazardous), after their closure and surrender of their operating permit. Therefore, in accordance with Principle 3, we do not expect operators to take account of non-radiological hazards in any assessments of inadvertent human intrusion.

Requirement R12. Natural disruptive processes after release from radioactive substances regulation: application of risk guidance level and dose guidance level

A4.84 **Operators should show in the SWESC that people will be adequately protected in the case of natural disruptive processes which expose radioactive waste or contamination, or impair protective barriers after the site is released from radioactive substances regulation.**

A4.85 A nuclear site may eventually be subject to natural disruptive processes after release from RSR. In particular, many nuclear sites are in coastal or estuarine locations, or are adjacent to waterbodies. 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. Examples of other natural disruptive processes include seismic activity, or disruption by non-human organisms, such as burrowing animals or the roots of plants. It is possible that buried radioactive waste or contamination might become exposed to the accessible environment by such processes while these substances still present a hazard.

A4.86 In assessing the consequences of natural disruptive processes, operators should not rely on the maintenance, beyond release from RSR, of engineered provisions such as sea or flood defences and drainage systems, except where operators can make a compelling case that such provisions will be maintained by society for other reasons, for example if they also protect a city.

A4.87 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 radioactive substances being exposed to the accessible environment. In such cases, operators should include suitable scenarios in the SWESC to assess the risks and should compare the results of the assessments with the risk guidance level (Requirement R10).

A4.88 In other cases, local concentrations of radioactive substances or radioactive articles may be uncovered and become accessible to people, who might receive a dose from them.

A4.89 The future behaviours of people that might lead to them encountering local concentrations of radioactive substances or radioactive articles uncovered by natural disruptive processes cannot be predicted, and so the probability of exposure cannot be quantified. In this respect, the exposure situation is similar to that of inadvertent human intrusion (Requirement R11). In both of these situations, dose is a measure of risk, but with the probability component necessarily absent.

A4.90 Therefore, for local concentrations of radioactive substances or radioactive articles, operators should carry out illustrative dose assessments, comparing the results of the assessments with the dose guidance level for inadvertent human intrusion (Requirement R11). Assessments should take into account radioactive articles that people might encounter as a result of natural disruptive processes uncovering them. Assessments should consider the possibility of ingestion or inhalation as appropriate. Radioactive articles might also include objects that would be visually identifiable and attractive to people.

A4.91 When applying the dose guidance level in the range of around 3 mSv/y to around 20 mSv in total we consider that values towards the lower end of this range are likely to be more applicable. This is because where natural disruptive processes uncover local concentrations of radioactive substances or radioactive articles, most exposure scenarios are likely to be prolonged exposures. The upper value of the range applies to possible scenarios with only short-term exposures.

Requirement R13. Optimisation of on-site disposals

A4.92 **Operators shall, through a process of optimisation, ensure that the radiological risks to individual members of the public and the population as a whole, from the on-site disposal of radioactive waste, are kept as low as reasonably achievable (ALARA) taking into account economic and social factors. Radiological risks shall be optimised throughout the period of radioactive substances regulation and afterwards, as far as can be judged at the time when relevant actions are taken. The process should also consider the need to manage radiological risks to other living organisms and to manage the non-radiological hazards associated with radioactive waste.**

A4.93 Optimisation of on-site disposals of radioactive waste is about ensuring that the particular way in which radioactive waste is disposed of keeps radiological risks to individual members of the public and the population as a whole ALARA throughout the period of RSR and afterwards. Where the optimisation of waste management options undertaken to fulfil Requirement R1 has determined that an on-site disposal option is the best overall, the operator should consider what more can be done in the specific design, construction and implementation of that disposal, to ensure exposures are ALARA.

A4.94 The dose constraints (see Requirement R9) place upper bounds on optimisation during the period of RSR. For the period after release from RSR the risk and dose guidance level apply (see Requirements R10, 11 and 12). Operators may take measures, during decommissioning and clean-up under RSR, to reduce the probability, post-RSR, that an exposure will be received, and to reduce the potential magnitude of the exposure. 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.

A4.95 Operators should assess ways to optimise protection of people and the environment in the design and implementation of the individual disposal by considering aspects such as:

- decontamination of structures prior to disposal in situ (for example decontamination or removal/scabbling of a fuel storage pond's inner surface)
- choosing an emplacement method which minimises and delays release of radionuclides (such as emplacement of activated concrete as blocks instead of as crushed material if practicable to do so)
- treating or isolating waste (such as grouting up of pipelines)
- capping of structures to minimise and delay entry of water and reduce likelihood of inadvertent human intrusion
- disabling preferential pathways such as drains
- enhancing or implementing engineering (for example lining of structures, impermeable layers, cut-off walls and active barriers)

A4.96 Operators' assessments of the optimised disposal option for buried waste should consider all reasonably practicable measures that could be taken to stabilise or immobilise buried radioactive waste, for example, infilling of cavities or grouting of pipes.

Requirement R14. Protection of the environment

A4.97 **Operators shall assess the radiological effects of the site on the environment with a view to showing that all aspects of the environment are adequately protected, both during the period of, and after release from, radioactive substances regulation.**

A4.98 Discharges and migration of radionuclides on or from a decommissioned site might have a detrimental effect on the environment, through effects on non-human organisms. This requirement aims to ensure that all aspects of the environment are protected.

A4.99 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. We will only authorise disposals and release sites from regulation when we are satisfied that these provisions are met.

A4.100 At the time of publication there are no statutory criteria for determining radiological protection of the environment, though some criteria have been recommended by IAEA (1992, 1998) and ICRP (2008, 2014). A number of research studies and regulatory guidance documents have proposed criteria and assessment approaches (for example Copplestone et al., 2001; Andersson et al., 2008; Brown et al., 2016). We currently use 'Environmental Risk from Ionising Contaminants: Assessment and Management' (ERICA) (Brown et al., 2016) for our own assessments of radiological impacts of discharges upon non-human organisms. When making an initial assessment of the dose rates from a single premises we use simplified assumptions and a dose rate screening criterion of 10 µGy/h for populations of non-human organisms in designated conservation sites (for example Sites of Special Scientific Interest, Special Areas of Conservation and Special Protected Areas). We consider this value sufficiently cautious that, if it is not exceeded, we would not expect populations of non-human organisms and their habitats to be adversely affected by the discharge. Should this screening criterion be exceeded, we would then use more site-specific data and the ERICA model to generate more realistic assessments.

A4.101 We expect operators to carry out an assessment and to draw conclusions about the effects of the site on the environment using the best information available at the time. Particular consideration should be given to the effects on designated conservation areas on or near the site. Operators 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.

Requirement R15. Protection against non-radiological hazards

A4.102 **Operators shall bring their 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.**

A4.103 Some radioactive substances remaining on a site may be potentially harmful partly because of their non-radioactive properties. There are nationally acceptable assessment approaches and standards for managing such hazards. 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 consistent level of protection should be provided against the non-radiological hazards.

A4.104 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.

A4.105 The SWESC should demonstrate that adequate protection is achieved against non-radiological hazards associated with the radioactive waste or contamination, using methods and approaches suited to the nature and proportionate to the magnitude of the non-radiological hazards. The methods and approaches should also be suited to the characteristics of the site.

A4.106 If the non-radiological hazards of the site persist beyond the radiological hazards, the site will continue to be regulated under an appropriate permit. We will not leave a site unregulated if there are hazards remaining.

Annex B Basis for the environment agencies' quantitative criteria

B1 Introduction

B1.1 This annex explains the basis for the numerical criteria specified in this guidance at Requirements R9, R10, R11 and R12.

B1.2 This annex outlines the international and domestic legal framework for protecting the public from exposures to ionising radiation that arise, or may arise, from authorised disposals of radioactive waste. It also summarises key international and national recommendations and guidance, as well as statements of national government policy, which we must have regard to in fulfilling our legal obligations.

B1.3 This annex explains how we fulfil each of our legal obligations regarding radiation protection through application of the requirements in this guidance.

B2 International radiation protection framework

B2.1 The international radiation protection framework is established in recommendations by the International Commission on Radiological Protection (ICRP), and in standards and guidance, which take account of ICRP recommendations, published by the International Atomic Energy Agency (IAEA).

B2.2 This framework is given legislative force throughout the European Union by Council Directive 2013/59/EURATOM (which repeals and replaces 96/29/EURATOM (EC, 1996)). This is also known as the Basic Safety Standards Directive, commonly abbreviated as BSSD.

Fundamental principles of radiation protection

B2.3 The ICRP framework sets out three principles of radiation protection, which can be summarised as follows:

- *Justification* - the social, economic and other benefit of practices must outweigh the health detriment arising from any associated radiation exposure
- *Optimisation* - all radiation exposures, to individual members of the public and to populations, shall be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account
- *Limitation* - radiation exposures to members of the public from all controllable sources must be kept below statutory limits

B2.4 The Justification of Practices Involving Ionising Radiation Regulations 2004 implements the justification principle in UK law. Under these Regulations, the relevant Secretary of State determines if a practice involving ionising radiation is justified. Radioactive waste management, including the disposal of solid radioactive waste, is considered to be an integral part of the practice giving rise to the waste and does not require separate justification. This principle is not discussed further in this annex.

B2.5 Our approaches to fulfilling the principles of optimisation and limitation are discussed further below.

Measures of radiation harm

B2.6 Two categories of health effects from radiation exposure are recognised by ICRP:

- Effects that have a threshold, above which the severity of the effect increases with dose. These are referred to as deterministic effects or harmful tissue reactions which are not expected to occur at absorbed doses of less than 100 milligray (mGy).
- Effects with no threshold, for which the probability of occurrence, but not severity, is related to dose. These effects, termed stochastic effects, are the induction of cancer and the induction of heritable effects. It is this category of effect that is of most relevance to the low levels of exposure typically associated with environmental exposures and their regulation.

B2.7 The main measure of harm to people from environmental exposures to ionising radiation is effective dose which has the unit the sievert (Sv). For comparison with statutory or regulatory criteria, doses are often more conveniently expressed in terms of thousandths of a sievert; or millisieverts (mSv).

B2.8 The ICRP (2007) maintains that for radiation protection purposes a linear no-threshold model is appropriate for estimating stochastic effects at low doses of below 100 mSv and recommends a coefficient of 0.05 per Sv should be used to assess the risk of exposure. Public Health England has advised on the application of ICRP Publication 103 in the UK that the most appropriate risk coefficient to estimate lifetime detriment is 0.057 per Sv, rounded up to 0.06 per Sv for waste disposal assessments. Our guidance is in accordance with this advice.

B2.9 Thus exposure of an individual to a dose of 2 mSv/y, the UK annual average dose from terrestrial background radiation, carries a risk (primarily of fatal cancer) of around one-in-10,000 per year (or 10^{-4}/y).

B3 National regulatory and policy framework

B3.1 The main requirements of BSSD relevant to public protection are transposed in Scotland by the Radioactive Substances Act 1993 (RSA 93) and by the Radioactive Substances (Basic Safety Standards) (Scotland) Direction 2000, and in England and Wales by the Environmental Permitting Regulations 2016 (EPR 2016).

B3.2 In carrying out our duties under this legislation, we take account of recommendations, principles, standards and guidance published by ICRP and IAEA.

B3.3 At the national level we also take account of advice issued by Public Health England's Centre for Radiological, Chemical & Environmental Hazards (PHE-CRCE, formerly the Health Protection Agency (HPA)), which has a statutory role to advise UK government and the devolved administrations on protection of the public from radiation and on the suitability of international recommendations and standards to the UK.

B3.4 Three government policy statements play a key role in our approach to regulation of radioactive waste disposal:

- Cm 2919: Review of Radioactive Waste Management Policy: Final conclusions. (HMSO, 1995)
- Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom' (Defra, 2007)

- The Decommissioning of the UK Nuclear Industry's Facilities (UK Government and the Devolved Administration, 2004)

B4 The main relevant provisions of the BSSD

B4.1 This section summarises the main provisions set out in 2013/59EURATOM of relevance to this guidance; similar provisions are currently in place in 96/29/EURATOM.

B4.2 Article 6 requires Member States to establish dose constraints as operational tools for optimisation of protection from exposures from specified sources.

B4.3 Article 12 requires Member States to ensure all exposures to a member of the public from authorised practices do not exceed a dose limit of 1 mSv/y.

B4.4 Article 28 (b) & (e) identifies both the operation and decommissioning of nuclear facilities, and the operation, decommissioning and closure of facilities for the storage or disposal of radioactive waste (above exemption levels), as practices that require to be authorised.

B4.5 2013/59/EURATOM recognises a number of different types of exposure situation. Exposures arising from authorised practices must be managed as 'planned exposure situations' (Article 4. (65)).

B4.6 Planned exposure situations (Article 4. (62)) may be further categorised as 'normal' or 'potential' exposure situations:

- Normal exposure situations (Article 4. (56)) are those expected to occur from normal operation of a facility
- Potential exposure situations (Article 4. (63)) are those not expected to occur with certainty but may result from an event or sequence of events of a probabilistic nature

B5 Our approach to regulating normal exposures

Limitation of exposures

B5.1 We are required (Radioactive Substances (Basic Safety Standards) (Scotland) Direction 2000 and EPR 2016) to ensure that the sum of the doses to any member of the public does not exceed the 1 mSv/y statutory dose limit specified in the BSSD (Article 12).

B5.2 A combination of prospective radiological assessment (prior to granting authorisation) and retrospective radiological assessment (based on monitoring of discharges and of radioactive substances in the environment) is used to show that doses arising from authorised disposals of radioactive waste are well below the statutory dose limit, and therefore that Article 12 of BSSD is satisfied.

Optimisation of exposures

B5.3 We are required (Radioactive Substances (Basic Safety Standards) (Scotland) Direction 2000 and EPR 2016) to have regard to the following dose constraints to individual members of the public 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

B5.4 The dose constraints place upper bounds on exposures that can arise from a single source and a single site during the operational and decommissioning period. Our Requirement R9 specifies these dose constraints as the radiological protection standard that has to be met during the period of RSR.

B5.5 We require applicants for authorisation to dispose of radioactive waste to perform prospective radiological assessments to demonstrate compliance with the dose constraints.

B5.6 We also give effect to the principle of optimisation by imposing appropriate limitations and conditions in permits granted to operators. This ensures the dose constraints cannot be exceeded, and that operators use best practicable means (Scotland) or best available techniques (England and Wales) to keep public exposures as low as reasonably achievable (ALARA). The principle of optimisation is specified in Requirements R1 and R13 of this guidance.

B5.7 The requirements specified in R9, and in R1 and R13, in this guidance, together fulfil the requirements of Article 6 of the BSSD.

B6 Our approach to regulating potential exposures

B6.1 After release from RSR, the dose limit and constraints that apply to normal exposures are no longer appropriate, since the site is no longer regulated and controlled. Any exposures that might arise in future are not certain to occur and must therefore be regarded as potential exposures.

B6.2 The BSSD, at ANNEX IX, requires applicants for authorisation to perform safety assessments of their activities and facilities which, among other things, must identify ways in which potential exposures could occur, and to estimate the probabilities and magnitudes of potential exposures.

B6.3 The requirement to estimate probabilities and magnitudes implies a risk-based approach to the assessment of potential exposures. That is to say, an estimate should be made of the radiological risk of an exposure scenario as the product of the assessed dose, the risk coefficient and the estimated probability of the exposure occurring, as follows:

- Assessed radiological risk (per year) = estimated dose (Sv per year) x risk coefficient (per Sv) x estimated probability of exposure

B6.4 The BSSD does not provide a standard to compare such risks against. However, the ICRP (2007), the IAEA (2014) and the UK's PHE-CRCE (HPA, 2009) have all produced recommendations, guidance and advice on the radiological protection standards that should apply to potential exposures to the public from disposal of solid radioactive waste. UK government has also published relevant policy (HMSO, 1995; Defra, 2007).

B6.5 Potential exposures need to be addressed under three different types of scenario:

- Exposures due to natural, undisturbed dispersal of radionuclides from undisturbed radioactive substances

- Exposures due to inadvertent human intrusion into radioactive substances remaining on the site
- Exposures due to natural disruptive events affecting radioactive substances remaining on the site

B7 Potential exposures due to natural dispersal of undisturbed radioactive substances after release from RSR.

B7.1 Once a site has been released from RSR it is, by definition, no longer subject to any controls or monitoring for the purpose of radiological protection of the public.

B7.2 The process of radioactive decay will continue to diminish the inventory of radioactive substances remaining on or adjacent to a site. Other natural physical and chemical processes will also affect this inventory. These processes will eventually degrade engineered barriers, and begin to mobilise and disperse a proportion of the remaining inventory within the accessible near-surface environment. In time, the mobilised radioactive substances have the potential to lead to exposures of people in the locality.

B7.3 The processes of mobilisation, dispersal and potential exposure of people are all subject to uncertainties in their timescales, probability and magnitude. However, they are amenable to probabilistic assessments of risk. Our Requirement R10 sets out our risk guidance level, and our expectations for how operators should assess the risks of natural dispersal of radionuclides from undisturbed radioactive substances.

Basis for risk guidance level

B7.4 ICRP (2007), IAEA (2014) and PHE-CRCE (HPA, 2009) all recommend a risk constraint (i.e. effectively a limit which should not be exceeded) of 10^{-5} per year.

B7.5 UK government has stipulated (HMSO, 1995) that, for potential exposures due to disposals of solid radioactive waste to land-based facilities, the regulators should apply a risk target of one-in-a-million per year (10^{-6} per year) of developing a fatal cancer or serious hereditary defect. If the regulators are satisfied that the operator has optimised protection of the public and the estimated risks are below this target, then no further reductions in risk should be sought. However, if the estimated risk is above this target, then the regulators will need to be satisfied, not only that an appropriate level of safety is assured, but also that any further improvements in safety could be achieved only at disproportionate cost.

B7.6 This value of 10^{-6} per year is consistent with advice given in the Health and Safety Executive (HSE) publication ‘Tolerability of Risk from Nuclear Power Stations’ (HSE, 1992) and reiterated in ‘Reducing Risks, Protecting People’ (HSE, 2001). The HSE 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 those risks, and below which, risks are broadly accepted by society because they are generally regarded as insignificant.

B7.7 In our guidance on requirements for authorisation of solid waste disposal (EA et al., 2009), and in this guidance, we have adopted the risk criterion of 10^{-6} per year, but have referred to it as a risk guidance level, rather than a target or risk constraint. We have chosen a risk guidance level to guide the operator towards a level of risk that we consider appropriate for the post-RSR phase. That is why our risk guidance level

is set an order of magnitude lower than PHE's risk constraint. It is neither a limit nor a constraint: it provides the environment agencies' broad expectations for the outcome of risk assessments relating to the post-RSR phase.

B7.8 This change in terminology is intended to better reflect the policy aim described at B7.5 above, that the guidance level should indicate the standard of environmental safety we are seeking, but should not suggest that there is an absolute requirement for the stated level to be met.

B7.9 Suitable risk assessments should identify and evaluate a sufficiently comprehensive range of exposure scenarios, and compare these with the risk guidance level. It is possible that a risk assessment, which demonstrates consistency with our 10^{-6} per year guidance level, may contain within it one or more scenarios in which a high dose (up to the deterministic effects threshold of 100 mSv) may occur but with a very low probability.

B8 Potential exposures due to inadvertent human intrusion into radioactive substances remaining on the site after release from RSR

B8.1 Decisions to dispose of solid radioactive waste in the near-surface environment, or to allow radioactive contamination to remain in the ground, are made on the basis that it remains isolated from people until sufficient time has passed, to allow radioactive decay to reduce the risks to people to levels that are no longer radiologically significant.

B8.2 Once a site has been released from RSR, the radioactive substances have the potential to be disturbed by people before it has decayed to insignificant levels. Such disturbance is termed human intrusion.

B8.3 Exposures due to inadvertent human intrusion, like those due to natural, undisturbed dispersal, are uncertain in timescale, probability and magnitude, and should, if practicable, also be assessed probabilistically.

B8.4 However, ICRP 1998, HPA 2009, IAEA 2011 and IAEA 2014 all advise that future actions by people, which might result in inadvertent human intrusion, are essentially unpredictable and therefore cannot be meaningfully quantified in terms of probability Instead, these bodies all recommend that the standard against which the consequences of inadvertent human intrusion should be assessed is dose. For this reason, our Requirement R11 is expressed as a dose, in units of mSv, rather than as a risk.

B8.5 Exposures due to inadvertent human intrusion are potential exposures, therefore assessed dose in this context is, in fact, a measure of risk, assuming that the exposure will certainly occur. These assessed doses should not, therefore, be compared against the statutory public dose limit of 1 mSv per year, but against a criterion that accounts for the inability to determine the probability of inadvertent human intrusion. Our standard expressed in Requirement R11 aims to do this by cautiously assuming, for the purposes of assessment, that inadvertent human intrusion will occur (ie. a probability of exposure of 1) and capping the dose that can be received in such a situation to a range of 3 to 20 mSv.

B8.6 Requirement R11 sets out our dose guidance level, and our expectations for how operators should assess the risks of inadvertent human intrusion. The primary purpose of specifying this standard is to prevent people being exposed to unacceptable risks even if the barriers or measures, intended to protect them from

radioactive substances, are inadvertently bypassed or impaired. Application of the dose guidance level places upper bounds on such risks, by effectively restricting the activity concentration of radioactive waste that can be authorised for disposal and of radioactive contamination that can be allowed to remain in the near-surface environment.

B8.7 This restriction on activity concentration provides an additional level of protection of people against risks of indefinable probability that cannot be achieved by application of the risk guidance level alone.

Basis for dose guidance level

B8.8 HPA 2009 explains the derivation of the range we use for our dose guidance level. It describes how these maximum doses, defined within the range 3 - 20 mSv, are intended to protect people inadvertently exposed to ionising radiation from radioactive waste due to an intrusion event, after the site has ceased to be regulated and controlled. It emphasises the need to control the potential doses in such an eventuality, because the probability of exposure cannot be defined.

B8.9 It recognises the need to address a variety of exposure situations of differing duration. It therefore recommends that the lower end of this range (3 mSv/y) is applicable to assessed exposures continuing over a prolonged period; a year or more, while the upper end of the range (20 mSv) is only applicable to assessed exposures that are short-term (transitory).

B8.10 If assessed doses from prolonged exposures were close to 3 mSv/y, or those from transitory exposures were close to 20 mSv, we would expect operators to consider ways to reduce the dose and/or the likelihood of receiving the dose, such as disposal of radioactive waste by another method, or greater clean-up of local concentrations of contamination. Exposures exceeding these levels indicate that disposing of that radioactive waste in that manner and location, or leaving that radioactive contamination on or adjacent to the site, are not acceptable options.

Comparison of dose guidance level with criterion for radioactive contaminated land.

B8.11 This guidance should not be confused with the radioactive contaminated land regime. The key difference is that:

- the dose guidance level for inadvertent human intrusion is intended to place a constraint, in the planning stages for decommissioning and clean-up, on the activity concentrations in radioactive waste and contamination that may be allowed to remain on-site, and so place constraints on the potential exposures that might arise if an event of indefinable probability were to occur

whereas

- the dose criterion for the potential designation of radioactively contaminated land is intended to set a threshold for exposures, which are certain or likely to occur, in an existing exposure situation above which intervention measures to avert exposure should be considered, though not necessarily implemented (HPA, 2006)

B9 Potential exposures due to natural disruptive events affecting radioactive substances remaining on the site

B9.1 Requirement R12 sets out the protection standards we apply to potential exposures due to natural disruptive events affecting radioactive substances that remain on the site after the end of RSR.

B9.2 We apply the risk guidance level (10^{-6} per year) specified in Requirement R10 to potential exposures to radioactive substances that, as a result of possible natural disruption, become relatively homogenously dispersed in the accessible environment.

B9.3 We apply the dose guidance level (3 mSv/y - 20 mSv) specified in Requirement R11 to potential exposures in which, as a result of possible natural disruption, (a) localised concentrations of radioactive substances are exposed to the accessible environment, and (b) radioactive articles become accessible to people.

Annex C References, Glossary and Acronyms

C1 References

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C2 Glossary of terms

Accessible environment
Those parts of the environment in contact with or readily available for use by humans and non-human organisms.

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*.

Directive waste
Any substance or object which the holder discards or intends or is required to discard, subject to the exclusions and definitions laid down in Article 2 of Directive 2008/98/EC.

Disposal
The permanent removal, deposit, destruction, discharge or burial of *radioactive waste*, without intent to retrieve it at a later time. Includes deposit of waste in a *disposal facility*, *disposal for a purpose* and *disposal in situ*.

Disposal facility
An on-site engineered facility where solid *radioactive waste* is permanently emplaced solely for the purpose of disposing of that waste.

Disposal for a purpose
On-site *disposal* of solid *radioactive waste* by permanent deposit where, if suitable *radioactive waste* were not available, other materials would have to be found to fulfil the purpose.

Disposal in situ
On-site *disposal* of solid *radioactive waste*, such as a buried structure, by leaving it permanently in position, together with any necessary preparatory works.

Dose guidance level (for *inadvertent human intrusion*)
The dose standard against which the radiological consequences of *inadvertent 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
A documented set of claims, made by the developer or operator of a *disposal facility*, to demonstrate achievement of the required standard of *environmental safety*.

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 e*nvironmental safety*, such as the geology providing a physical barrier function and also having chemical properties that help to retard the migration of radionuclides.

Expert judgement
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.

Groundwater protection legislation
This describes the most relevant legislation for the protection of groundwater:

In England and Wales:

- Schedule 22 to the Environmental Permitting (England and Wales) Regulations 2016 (relating to 'groundwater activity')
- Water Environment (Water Framework Directive) (England and Wales) Regulations 2017

In Scotland:

- Water Environment and Water Services (Scotland) Act 2003
- Water Environment (Diffuse Pollution) (Scotland) Regulations 2008
- Water Environment (Controlled Activities) (Scotland) Regulations 2011
- Water Environment (Controlled Activities) (Scotland) Amendment Regulations 2013

- Water Environment (River Basin Management Planning etc.) (Miscellaneous Amendments) (Scotland) Regulations 2015

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

Inadvertent human intrusion
Any human action that unintentionally disturbs *radioactive substance*s, or that impairs a barrier or measure providing an *environmental safety function,* after the release from RSR.

Low level waste (LLW)
Defined in government policy 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'.

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
Continuous or periodic observations and measurements by which the operator maintains awareness of the condition of the *site* and any changes to that condition, and where relevant the surrounding area to help evaluate the impact of the *site*.

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 licensed site (definition from RSA 93 or EPR 2016)
(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, and
"licensee", when used in relation to a *nuclear site*, and "*period of responsibility*" have the same meaning as in the Nuclear Installations Act 1965.

Nuclear site
The piece of land delineated by the environmental permit as constituting the authorised premises. Therefore, nuclear site and *site* have the same meaning in this guidance. The authorised premises may not always be identical to the *nuclear licensed site*, for example it may include extensions to include pipelines and drains.

Optimisation
The principle of ensuring that all exposures to ionising radiation of any members of the public and of the population as a whole are kept as low as reasonably achievable (ALARA), economic and social factors being taken into account. Optimisation is one of the basic principles of radiation protection recommended by the International Commission on Radiological Protection (ICRP) and incorporated into UK law.

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 responsibility
As defined in the Nuclear Installations Act 1965, as amended by paragraph 20 of Part 2 of Schedule 12 to the Energy Act 2013.

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

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.

Radioactive contamination
Any substance in situ in the ground or groundwater that would, if it were removed from the ground or groundwater, satisfy the definition elsewhere in this glossary of *radioactive waste*.

Radioactive material
Any substance or article which is not waste, and which satisfies Section 1A of the Radioactive Substances Act 1993 or paragraph 3(1), Part 2, Schedule 23 of the Environmental Permitting (England and Wales) Regulations 2016. The environment agencies do not regulate the keeping and use of radioactive material by the nuclear licensee on *nuclear sites*; this is the responsibility of ONR. The environment agencies are interested in radioactive material to the extent that it may become *radioactive waste*.

Radioactive substances
Any substance or article that satisfies the definitions elsewhere in this glossary of *radioactive material* or *radioactive waste* or *radioactive contamination*.

Radioactive waste
Any substance or article which is waste, and which satisfies Section 1A of the Radioactive Substances Act 1993 or Paragraph 3.(1), Schedule 23 of the Environmental Permitting (England and Wales) Regulations 2016.

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.

Representative person
An individual receiving a dose that is representative of the more highly exposed individuals in the population (see Publication 101, ICRP 2006). This term is the equivalent of, and replaces, 'average member of the critical group' described in previous ICRP Recommendations. This term is also the equivalent of 'potentially exposed group', used in other guidance to define a group representative of the more highly exposed individuals in the population, but for whom exposure is not certain to occur.

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.

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

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

Site
Where used as a single word and not as part of a term included elsewhere in this glossary, site means the piece of land that is delineated by the environmental permit as constituting the authorised premises. Therefore site and *nuclear site* have the same meaning in this guidance.

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 reference state
The condition of a *nuclear site* when it is fully compliant with the requirements for release of the *site* from RSR. This condition may be achieved after an operator has completed all planned work involving *radioactive substances*, or after a subsequent period of control for the purpose of radiological protection.

Site-related dose constraint
The maximum effective dose (0.5 mSv/y) to a *representative person* arising from the aggregate exposure to discharges from a number of sources with contiguous boundaries at a single location. It applies only during the period of regulation. It includes the radiological effects of current discharges from the entire *site*, but excludes the effects of historical discharges. The site-related constraint applies irrespective of whether different sources on the *site* are owned and operated by the same or by different organisations.

Site-wide environmental safety case
A documented set of claims, made by the operator of a *nuclear site*, to demonstrate achievement by the site as a whole of the required standard of e*nvironmental safety*. Where relevant, the SWESC includes the *environmental safety case* for any on-site *disposal facility*. The SWESC also takes account of contributions to the combined impact on *representative persons* from adjacent *nuclear sites*, and from areas of contamination and previously permitted disposals outside the *site.*

Source-related dose constraint
The maximum effective dose (0.3 mSv) to a *representative person* arising from exposure to discharges from a facility, or group of facilities within a *site* which can be optimised as an integral whole in terms of *radioactive waste* disposals. It applies only during the period of regulation. It includes the radiological effects of current discharges from the source, but excludes the effects of historical discharges.

Stakeholder
People or organisations, having a particular knowledge of, interest in, or potentially being 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* (such as 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
Close observation of specified aspects of the *nuclear site* by the operator during the lifetime of the permit. After the completion of all planned work involving *radioactive substances*, surveillance is needed during any period of control to ensure that the assumptions in the SWESC remain valid. 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.

Uncertainty / Uncertainties
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.

Validation monitoring
Monitoring to confirm that the condition and behaviour of the *site* and where relevant the surrounding area, 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 completion 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
A documented plan, prepared by the operator of a *nuclear site*, which provides a comprehensive description of the current intent for dealing with all *radioactive substances* on or adjacent to the *site* and demonstrates how waste management has been optimised.

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

C3 Acronyms

ALARA	As low as reasonably achievable
BEIS	The Department for Business, Energy and Industrial Strategy
BSSD	Basic Safety Standards Directive
CEPN	Centre d'études sur l'évaluation de la protection dans le domaine nucléaire
CSM	Conceptual site model
Defra	Department for Environment, Food and Rural Affairs
DoWCoP	Development Industry Definition of Waste Code of Practice
EA	Environment Agency
EC	European Commission
EPR 2016	Environmental Permitting (England and Wales) Regulations 2016
ERICA	Environmental Risk from Ionising Contaminants: Assessment and Management
ESC	Environmental Safety Case
EURATOM	European Atomic Energy Community
HPA	Health Protection Agency (now Public Health England)
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
LLW	Low-level radioactive waste
NIA 65	Nuclear Installations Act 1965
NICoP	Nuclear Industry Code of Practice
NRW	Natural Resources Wales
NS-GRA	Near-Surface Guidance on Requirements for Authorisation
ONR	The Office for Nuclear Regulation
PHE	Public Health England (formally Health Protection Agency)
PHE-CRCE	Public Health England's Centre for Radiological, Chemical & Environmental Hazards
RSA 93	Radioactive Substances Act 1993
RSR	Radioactive Substances Regulation
RWMC	Radioactive Waste Management Case
SEPA	Scottish Environment Protection Agency
SWESC	Site-Wide Environmental Safety Case
WAC	Waste Acceptance Criteria
WMP	Waste Management Plan