Environment Agency

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Developing guidance for setting limits on radioactive discharges to the environment from nuclear-licensed sites

Science Report: SC010034/SR

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Steve Killeen

Head of Science

Executive Summary

The guidance described in this report has been developed to provide assistance to Environment Agency nuclear regulators, to promote and maintain consistency in limit setting and to inform others about the Agency's methodology for limit setting. It deals with setting discharge limits for airborne and liquid radioactive effluents for nuclear-licensed sites. This report is divided into two parts:

Part I – General principles and context for setting discharge limits

Part I begins by identifying both the general and specific **environmental protection principles** used by the Environment Agency for setting discharge limits within authorisations issued under the Radioactive Substances Act 1993. The *general* principles are those of sustainable development and of human rights – principles which shape the Environment Agency's overall approach to setting discharge limits. The *specific* principles are those, which are used directly in setting limits, and concern:

- waste minimisation
- progressive reductions in discharges
- radiological protection of the public
- health and safety considerations
- protection of non-human species
- people's use of the environment
- protection beyond national borders
- precautionary action.

This report explains how implementing these specific environmental protection principles involves two approaches: 'best practicable means' (BPM), and 'best practicable environmental option' (BPEO). It then goes on to identify the general and specific **regulatory principles** used in setting discharge limits, and explains how these are implemented – including through the use of a template authorisation.

Part II – Methodology for setting discharge limits

Part II begins by considering the setting of discharge limits within the context of the Environment Agency's regulatory activities at nuclear-licensed sites. It then goes on to describe a recommended methodology for setting annual discharge limits which includes the following steps:

- identifying the plants on sites for which annual limits are to be set, bearing in mind the need to segregate discharges;
- establishing worst case plant discharges based on information provided by the operator, together with Environment Agency judgements;
- identifying the radionuclides for which plant limits are to be set;
- deriving proposed discharge limits for the plants identified;
- deriving proposed discharge limits for whole sites;
- estimating the impacts of future discharges on people and the environment.

The final sections of Part II deal both with setting other limits and levels – including, for example discharge caps for new plant, or setting short-term limits – and with assessing the economic impacts of proposed discharge limits on the operator.

Contents

1. Introduction

The guidance developed in this report has three purposes:

i) to provide assistance to Environment Agency nuclear regulators in setting limits in radioactive discharge authorisations for nuclear-licensed sites, particularly in the light of the forthcoming Statutory Guidance on this issue;

ii) to promote and maintain consistency in limit setting;

iii) to inform others about the Environment Agency's limit setting methodology.

At the outset of this project it was anticipated that the Statutory Guidance would be published during its course. However, given that this has not yet occurred, this report has been based on the consultation versions of the Statutory Guidance [DETR 2000; Welsh Assembly 2000]. Thus, the guidance provided in this report must be regarded as being in draft form.

The draft guidance deals solely with setting discharge limits for airborne and liquid radioactive effluents. It does not address other aspects of revising or issuing authorisations under the Radioactive Substances Act 1993 (RSA 93) for nuclear-licensed sites (such as setting limits for solid waste disposals; setting the terms of, and conditions in, authorisations; consultation on authorisations). Neither does it address other aspects of the regulation of these sites (such as inspection and enforcement under either RSA 93 or the Pollution Prevention and Control (PPC) regime).

The report is divided into two parts:

- Part I – General principles and context for setting discharge limits
- Part II – Methodology for setting discharge limits

Part I – General and specific principles for setting discharge limits:

2 Environmental protection principles

This section sets out the *general* **environmental protection principles** that the Environment Agency uses to set discharge limits in authorisations under RSA 93 (RSA authorisations). It also describes the more *specific* environmental protection principles**,** which are directly applied in setting limits. These include those mentioned in the consultation versions of the Statutory Guidance [DETR 2000; Welsh Assembly 2000[1]], as well as other principles that have their origin in legislation, government policy and best practice. The term 'environmental protection' is taken to include the protection of human health, together with the health of other living organisms, natural ecosystems, the land (including surface water and groundwater) and the seas.

2.1 General principles

The general principles for environmental protection are those that shape the Environment Agency's overall approach to setting discharge limits. They are not used directly in setting limits, but rather underlie the more specific principles (see section 2.2) that are applied. Moreover, checks are made at the end of limit setting to ensure that the general principles have not been inadvertently contravened. This forms part of an overall assessment to ensure that the proposed limits satisfy all the elements of the legal and policy framework for decision making under RSA 93.

2.1.1 Sustainable development

The principal aim of the Environment Agency – as set out in the Environment Act 1995 (EA 95) – is to contribute to sustainable development. The draft Statutory Guidance [DETR 2000] states that the Government's general approach to sustainable development (described in Cm 4345 [1999]) applies to sectors of the economy that deal with radioactive materials; hence, it applies to nuclear-licensed sites. Moreover, 'putting people at the centre' lies at the heart of sustainable development; hence, it must enable people to enjoy a better quality of life, both now and in the future [Cm 4345, 1999].

[1] For simplicity, we refer only to the draft Statutory Guidance for England (DETR 2000), except where the draft Statutory Guidance for Wales (Welsh Assembly 2000) is substantially different.

In contributing to sustainable development, the Environment Agency must, therefore, take account of both costs and benefits [Environment Act 1995]. The range of the costs and benefits considered must be both wide and include those that cannot easily be valued in terms of money (see Cm 4345 [1999] and the draft Statutory Guidance). Throughout its work, the Environment Agency uses the 'polluter pays' principle.

2.1.2 Human rights

The Human Rights Act 1998 requires that public bodies, such as the Environment Agency, should act in a way that is compatible with those articles of the European Convention on Human Rights that are specified in the Act. Some Convention rights, such as the right to life, are absolute; others, such as the right to home and private life, are qualified. The Environment Agency must consider whether its decisions in respect to an RSA authorisation will result in any potential or actual breach of a Convention right, but its primary obligation is to fulfil its statutory duty.

2.2 Specific principles

The more specific environmental protection principles are those that are used directly in setting discharge limits. These specific principles are set out below, while section 3 details how these principles are implemented.

2.2.1 Waste minimisation

The principle that wastes should not be created unnecessarily has featured in both Government policy and Environment Agency practice for many years. It is stated explicitly in Cm 2919 (1995) for radioactive wastes, as well as in various policy and guidance documents for non-radioactive wastes (see, for example, *Waste Strategy 2000* [Cm 4693, 2000]. The principle of waste minimisation applies to solid, liquid and airborne wastes, both individually and together.

2.2.2 Progressive reductions in discharges

The principle that there should be progressive reductions in radioactive discharges is central to the UK Discharge Strategy [DEFRA 2002a], and has been a feature of government policy since 1993 [DoE 1993]. Linked to this principle is the preference to 'concentrate and contain' rather than 'dilute and disperse' that features in the draft Statutory Guidance of the Department of Environment, Transport and the Regions (DETR). The principle of progressive reductions applies to discharges from nuclear sites as a whole, and to individual nuclear sectors and sites.

For liquid discharges to the marine environment, there are two general targets for discharge reductions. The UK is committed to implementing the OSPAR (Oslo and Paris Convention for the Protection of the Marine Environment of the North-east Atlantic) strategy for discharge reductions, which aims to add, by 2020, 'close to zero' man-made radionuclides to 'historic levels' in the marine environment [OSPAR 1998]. The UK Discharge Strategy contains a target, for critical group doses from liquid discharges, of less than 20 microsieverts per year by 2020. There are also liquid discharge targets for each nuclear sector in

the Strategy [DEFRA 2002a]. While it is for the Environment Agency to consider how to achieve these targets through limiting discharges at each site, overall compliance with both the UK Discharge Strategy and the OSPAR strategy is a matter for Government.

2.2.3 Radiological protection of the public

The main *radiological protection principles* relevant to setting discharge limits are that:

- doses to individuals must be within statutory limits – as given in the Ionising Radiation Regulations [1999] (IRR 99) and the European Basic Safety Standards Directive 96/29 (the BSS Directive);
- doses to individuals from discharges should be within the constraints set out in the Radioactive Substances (Basic Safety Standards) Direction 2000 (the BSS Direction);
- all doses should be as low as reasonably achievable (ALARA), economic and social factors being taken into account (see the BSS Direction and the BSS Directive).

These principles apply in the short term and in the long term.

2.2.4 Health and safety considerations

The relevant *health and safety principles* are that: routine doses to individual workers should be within the dose limits given in IRR 99; that all routine doses to workers should be as low as reasonably practicable (ALARP), and that risks, from potential accidents, to workers, the public and the environment, should be ALARP [HSE 1992]. In accordance with a memorandum of understanding, the Environment Agency liaises with the Health and Safety Executive (HSE) regarding matters of mutual concern at nuclear-licensed sites. The Environment Agency is required to ensure that any changes in worker exposure (i.e. additional or continued exposures) or accident risk, which result from discharge reductions, are not disproportionate to the benefits of those reductions in terms of protecting the public and the environment [DETR 2000].

2.2.5 Protecting non-human species

The principle here is that discharges should not jeopardise communities of non-human species [DETR 2000]. It is used in all of the Environment Agency's work, and features in much European Union (EU) legislation (see, for example, the Habitats Directive [1992] and its Regulations). While at present there are no determined 'dose limits' for non-human organisms, enough is known about radiation effects to perform assessments, of whether future discharges might jeopardise such communities.

2.2.6 People's use of the environment

The relevant principle is that discharges should pose no threat to (i.e. they should not prejudice) legitimate uses of the land (including surface water and groundwater) and the seas. This principle follows from that of sustainable development (see section 2.1). It is included in the draft Statutory Guidance [DETR 2000] and in the OSPAR strategy [OSPAR 1998]. It also features in

other Environment Agency work, such as that carried out under the PPC regime. Linked to this principle is the target, in the draft Statutory Guidance, that radionuclide concentrations in foods should not exceed European Community food intervention levels (CFILs) [Commission of the European Communities 1989].

2.2.7 Protection beyond national borders

This principle, as stated in the draft Statutory Guidance, is that the Environment Agency should take account of possible radiation exposures of groups of people outside the UK. This has long been a feature of both European Union requirements – as, for example, under Article 37 of the Euratom Treaty (see Commission of the European Communities [1991]) – and international radiological protection principles [IAEA 1995].

2.2.8 Precautionary action

The precautionary principle is that 'where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation' [United Nations 1992]. A key element of the UK strategy for sustainable development [Cm 4345 1999], this principle is included in the draft Statutory Guidance [DETR 2000], and has been a feature of UK policy on radioactive waste management for some years [Cm 2919 1995].

3 Implementing environmental protection principles: BPM and BPEO approaches

3.1 Scope of approaches

The ‘best practicable means’ (BPM), denotes the level of management and engineering control that minimises, as far as is practicable, the release of radioactivity into the environment, whilst taking account of a wider range of factors, including cost-effectiveness, technological status, operational safety, and social and environmental factors (see Cm 2919 [1995]). In determining what the BPM are, the Environment Agency does not require that the licensee incurs any expenditure – whether in money, time or trouble – which is (or is likely to be) grossly disproportionate to the potential benefits anticipated.

The ‘best practicable environmental option’ (BPEO) approach derives from recommendations from the Royal Commission on Environmental Pollution [RCEP 1988]. The Commission defined the BPEO as the option that ‘provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as in the short term’. The definition currently used by the Environment Agency, in the context of radioactive waste management, is that the BPEO is the option that ‘provides the most benefit or least damage to the environment as a whole in the long term as well as in the short term, taking into account operational doses and risks, and social and economic factors’. When applied together, the BPM and BPEO approaches are regarded as equivalent to the ‘best available techniques’ (BAT) approach, as defined and used in the IPPC Directive [1996].

The BPM and BPEO approaches are applied to plants, processes and waste streams; they may also sometimes be applied to particular radionuclides within a set of waste streams. Both approaches involve comparing options on a wide range of factors, including radiological impact on people and the environment, non-radiological impacts on people and the environment, social factors and financial costs. The impacts to be included are: those in the short term and the long term; those in routine and accident situations; those on the public and on workers.

The requirement to use BPM applies to both the treatment of wastes prior to disposal and the method of operation of the process giving rise to the waste. Its application to methods of operation is dealt with in a general condition in all nuclear site authorisations that requires the operator to use BPM at all times (see section 5). The requirement to use the BPEO applies to choosing the best option either for treating waste, or for carrying out the operation that gives rise

to the waste. The BPM approach then applies to more detailed aspects of plants and processes, once the fundamental option has been determined.

Both the BPM and BPEO approaches are applied within the context of substantiated operator need. To gain an authorisation, the operator must demonstrate to the Environment Agency that: the operations giving rise to waste are, or will be, necessary; the BPEO has been chosen; the BPM will be used. Operators are required to consider a wide range of options in BPEO and BPM studies, taking into account both the best technology and techniques available now, and any technology and techniques that they could avail themselves of in the foreseeable future.

3.2 Role in the authorisation process

What constitutes the BPEO or BPM changes with time, as a result of, for example, technological advances. Operators are therefore required to carry out periodic BPEO and BPM studies for existing plant and processes. In general, for new plant, a BPEO study is required as input to *the broad choice of option*, while a BPM study is needed as input to *decisions on how that option is to be implemented*.

While authorisations for nuclear-licensed sites are reviewed regularly [DTI 2003], BPEO and BPM studies are carried out by operators between these regular reviews. The Environment Agency may include, in an authorisation, a requirement to carry out particular BPEO or BPM studies, or it may impose a requirement for particular studies through the general regulatory process. The Environment Agency then reviews the results of the operator's BPEO and BPM studies to reach a decision either on whether existing plants and processes need to be changed or replaced, or on which types of new plants should be introduced. The timescale for making any changes, replacements or introductions is agreed with the operator. All this takes place prior to setting numerical limits. In general, it will not be necessary to return to BPEO studies during the process of setting numerical limits, nor to major questions of BPM. However, it will be necessary to consider BPM at a more detailed level when setting numerical limits (see Part II).

As outlined above, by the time that setting numerical limits begins, major decisions about plants and processes – and hence about major discharge reductions (or increases) – will already have been taken. The limits are then set so as to reflect these decisions, and the authorisation becomes the main legal instrument by which operators are held to these decisions. Section 6 provides further details on this sequence of events.

In most cases there will be a delay between the Environment Agency's decision to require the operator to implement a major scheme to reduce discharges and the actual change to numerical limits in the authorisation. Typically, one review of the authorisation will impose a requirement to implement a scheme, while the subsequent review changes the numerical limits to correspond to what that scheme will achieve. The time allowed for implementation will be as short as is reasonably practicable.

Not every authorisation review will be preceded by large-scale BPEO or BPM studies, or major discharge decisions. For example, there will be instances where there is clearly no potential for substantial discharge reductions during the period to be covered by the next authorisation. However, in general the Environment Agency will time its reviews of authorisations to be consistent with plans for major changes on sites.

3.3 Types of sector, site and waste

The nuclear sectors specified in the UK Discharge Strategy [DEFRA 2002a] are: nuclear fuel production and uranium enrichment; nuclear energy production; spent fuel reprocessing; research; defence; manufacture of radioactive products (for medicine, pharmaceutical industry, academic research)[2]. Within each nuclear sector there could, in theory, be three types of site:

- operational sites
- sites being decommissioned
- mixture sites (where both operations and decommissioning are in progress).

'Decommissioning' denotes the set of actions taken at the end of a nuclear facility's operational life to take it permanently out of service. It includes actions to systematically and progressively reduce the level of hazard on a site, and may include the physical dismantling of the facilities. Decommissioning is not necessarily a single step process and may involve several stages spread over a number of years. The ultimate aim of decommissioning is to make the site suitable for other purposes [HSE 2001].

Over the course of their lives, nuclear-licensed sites change from one type to another. The current (early 2003) situation is as shown in Table 1, while Table 2 shows the types of waste that exist or arise at each type of site.

Table 1 Types of nuclear site in each sector

Nuclear sector	Operational sites	Decommissioning sites	Mixture sites
Fuel production and uranium enrichment	Springfields URENCO, Capenhurst	BNFL Capenhurst	

[2] While the Environment Agency also regulates other sectors (medical, research, industry), these are outside the scope of this guidance. In addition, there are many defence sites (mainly non-nuclear) that are outside scope of RSA but to which the Ministry of Defence, with the agency's agreement, applies principles that are the same as those used in regulation under RSA.

Nuclear sector	Operational sites	Decommissioning sites	Mixture sites
Energy production	Calder Hall Chapelcross Dungeness A & B Hartlepool Heysham 1 & 2 Hinkley Point B Hunterston B Oldbury Sizewell A & B Torness Wylfa	Berkeley Bradwell Trawsfynydd Hunterston A Hinkley Point A	
Spent fuel reprocessing			Sellafield
Research	Culham	Dounreay Winfrith	Harwell Windscale
Defence	Barrow Devonport Faslane Holy Loch Rolls Royce, Derby		Aldermaston & Burghfield Rosyth
Radioactive products	Amersham Amersham Cardiff	Amersham Harwell	

Table 2 Types of radioactive waste at each type of nuclear site

Type of site	Type of waste
operational	operational arisings from existing plant operational arisings from new plant legacy wastes
decommissioning	decommissioning wastes legacy wastes
mixture	operational arisings from existing plant operational arisings from new plant decommissioning wastes legacy wastes

Operational wastes are those arising from current operations of plant. Decommissioning wastes are those arising directly from decommissioning activities. Legacy wastes are wastes that arose from past operations. The legacy wastes of interest to discharge authorisations are those that require further treatment prior to disposal or long-term storage.

3.4 Applying environmental protection principles within BPEO and BPM determinations

The Environment Agency and the Scottish Environment Protection Agency (SEPA) have issued guidance to their nuclear regulators on both BPEO methodologies and BPM. This section of this report is intended to complement this guidance and addresses issues raised in the Environment Agency's stage 2 report on the financial, management and policy review [DEFRA 2002b].

3.4.1 Waste minimisation

The principle of waste minimisation (see section 2.2.1) applies at all nuclear-licensed sites. It applies to the creation of operational and decommissioning wastes, and to the creation of secondary wastes that may be produced when dealing with legacy wastes. The principle applies primarily to overall waste activities and volumes, but also to solid, liquid and gaseous wastes separately.

The BPM and BPEO approaches are used to determine how to minimise waste arisings and how far to go in minimisation. This can be done by including attributes to represent waste quantities (activities and volumes) when comparing options.

3.4.2 Progressive reductions in discharges

The BPM and BPEO approaches are used to determine how to achieve progressive reductions (see section 2.2.2) and how far to go at a particular site. The potential for discharge reductions is different at operational, decommissioning and mixture sites. At operational sites, existing operational plant may have potential for discharge reductions, whilst new plant and dealing with legacy wastes have potential for discharge increases. At decommissioning sites, decommissioning and dealing with legacy wastes may have potential for discharge increases, both in the short term and at various points in the decommissioning period. At mixture sites, existing operational plant may have potential for discharge reductions, whilst new plant, decommissioning and dealing with legacy wastes may have potential for discharge increases.

At operational sites, the Environment Agency will use BPEO and BPM to seek progressive reductions in liquid and airborne discharges, taking current levels as the reference point from which reductions are required. The overall aim will be to ensure that reductions at existing plant are greater than increases from both new plant and dealing with legacy wastes. This will not, in general, involve reducing every discharge limit on each occasion that an authorisation is reviewed. Given that both the BPEO and the BPM approaches involve consideration of financial costs, the decision of how far to go in reducing discharges at any particular time is made on the proviso that the costs of the reduction measures – in terms of money, time and/or trouble – should not be grossly disproportionate to the anticipated health, environmental and other benefits stemming from the reduction (see section 3.1).

It is not realistic to seek progressive reductions in discharges from the time at which operations on a site cease and throughout the decommissioning period.

Typically, site discharges will fall sharply when major plants stop operating, but will then need to increase again, for limited periods, as decommissioning proceeds. Imposing a regime of progressive reductions throughout this period would prohibit essential decommissioning work, contrary to government policy [Cm 2919 1995]. The Environment Agency will therefore use BPEO and BPM to seek low discharges from each type of decommissioning operation. It will permit discharge increases for limited periods, provided that there is a general downwards trend after the early phases of decommissioning, and that discharges never exceed those typical of the latter years of site operation.

Mixture sites will be treated as operational sites unless and until discharge reductions cannot be achieved without compromising agreed objectives of decommissioning and dealing with legacy wastes. They will then be treated as decommissioning sites.

The two general targets for 'progressive reductions' in liquid discharges to the marine environment (see section 2.2.2) are: a) by 2020, critical group doses should not exceed 20 μSv per year; b) discharges should be adding 'close to zero' to 'historic levels' in the marine environment. However, while there is ongoing DEFRA and OSPAR work to define 'historic levels' and 'close to zero', the outcome of this is not yet known. Meanwhile, for the next decade or so it will not be appropriate to give the 20 μSv per year target any constraining role in BPEO or BPM determinations. For the present, both of these general targets are best dealt with by including attributes to represent progress towards each target in option comparisons.

In addition to these general targets, the UK Discharge Strategy also includes liquid discharge targets for each nuclear sector [DEFRA 2002a]. These targets are framed in terms of the activity that could be discharged after particular times up until 2020. They are also set based on knowledge of planned abatement measures and plant closures, including the expenditure required [DEFRA 2002a]. The Environment Agency will check progress towards these targets when setting limits for particular sites.

The preference to 'concentrate and contain' rather than to 'dilute and disperse' [DETR 2000] influences which of the available options are selected to compare in detail in BPEO and BPM studies. Most practical options do not exclusively either 'concentrate and contain' or 'dilute and disperse', but more usually have elements of both. This situation is addressed by defining the degree to which an option allows the possibility to 'concentrate and contain' as an 'attribute' when comparing options. In this way, options with a greater propensity to 'concentrate and contain' are rated more highly than those with more potential to 'dilute and disperse'.

3.4.3 Radiological protection, and health and safety considerations

At a broader level, the principle of ALARA (see section 2.2.3) can be met using the BPEO and BPM approaches. Whilst it would be possible to compare options for ALARA, then compare them again for BPEO/BPM, it is more efficient

to do the comparison once in the broader framework of BPEO/BPM[3]. More detailed ALARA studies may then be needed. Worker exposures and risks from potential accidents are included in BPEO and BPM studies, such that they can be balanced against routine public exposures and other factors.

The IRR 99 dose limits for public and workers, and the 0.3 mSv and 0.5 mSv in RSA BSS Direction, act as constraints on the choice of options to compare in BPEO and BPM studies. Other constraints on option choice include the 'basic safety limits' (BSLs) which relate to potential accidents in the HSE Safety Assessment Principles (SAPs) for nuclear plant [HSE 1992]. In addition, when numerical limits are set, checks are made to ensure that discharges at those limits will not lead to dose constraints being exceeded (see Part II of this report).

3.4.4 Protecting non-human species

The principle that there should be no jeopardy to communities of non-human species constitutes a constraint on both BPEO and BPM (since no option should be chosen that would result in such jeopardy). It is applied by assessing impacts of options on non-human species and rejecting those that would jeopardise communities. In addition, impacts on non-human species are included as attributes when comparing options. Finally, when numerical limits are set, checks are made to ensure that discharges at those limits would not jeopardise communities (see Part II of this report).

3.4.5 Protecting legitimate uses of the land or the sea

Given that there are varying degrees of 'prejudice', the principle that there should be no prejudice to the legitimate uses of the land or the sea is applied in two ways. Firstly, it is used as a constraint on BPEO and BPM in the sense that no option should be chosen that would clearly give rise to severe prejudice. Secondly, attributes which relate to the degree of prejudice to legitimate uses of the land or the sea – such as the impacts on the local economy, or on people's way of life – are included in option comparisons.

One general target is that radionuclide concentrations in foods should not exceed CFILs [Commission of the European Communities 1989], and therefore do not prejudice food production and sale. CFILs may change and, for the present, this target is best dealt with by including an appropriate attribute in option comparisons.

3.4.6 Protection beyond national borders

This principle means that individuals and populations in other countries should receive doses that are acceptably low [DETR 2000]. It is dealt with by including these individual and population doses as attributes in option comparisons. If an *increase* in site annual discharge limits is proposed, the government is required to make a submission to the European Commission under Article 37 of the Euratom Treaty. The submission must include estimates, from discharges at the proposed limits, of doses in other European Union countries. The authorisation containing the higher limits cannot come into force until the

[3] This procedure is endorsed implicitly for BPM in the White Paper Cm 5552 [2002], which states that 'if the operator is using BPM, radiation risks to the public and the environment will be ALARA'.

submission has been reviewed by the Article 37 group of experts and the Commission has issued its opinion.

3.4.7 Precautionary action

This is a general principle that is borne in mind when choosing options to compare. However, it is mainly dealt with in BPEO and BPM studies by including an attribute for ‘degree of precautionary action’ when options are compared.

4. Regulatory principles and their implementation

This section sets out the *general* **regulatory principles** used by the Environment Agency in setting discharge limits in RSA authorisations. It also describes more *specific* principles. It includes principles mentioned in the draft Statutory Guidance [DETR 2000] and others that have their origin in legislation, government policy (including the *Better Regulation Guide* [1998]) and the agency's best practice.

4.1 General principles

4.1.1 Comprehensiveness

This principle requires the Environment Agency to use the most up-to-date information available on all the radioactive discharges from a site when setting authorisations [DETR 2000]. It is to be applied in framing qualitative requirements and conditions in authorisations (see section 5), and when setting numerical limits (see Part II).

4.1.2 Rigour

This principle requires the Environment Agency to review all the principal sources of discharges on a site, and to discriminate between operational, legacy and decommissioning wastes [DETR 2000]. Part II of this report shows how this is to be achieved. This principle also requires full examination and assessment of options for avoiding and reducing discharges, which is carried out through BPEO and BPM studies (see section 3).

4.1.3 Being prospective

This principle requires the Environment Agency to take account, both of an operator's current and future operations, and of any developments in technology [DETR 2000]. Again, this is achieved through BPEO and BPM studies (see section 3). The principle also specifies that authorisations should be set on the basis that they are expected to remain current for at least four years unless new and relevant factors come to light. This is already practice and will continue to be so.

4.1.4 Transparency

The publication of this report is intended to add to the required transparency of methodology for issue and review of authorisations [DETR 2000]. Publication of authorisation reviews and public consultation on authorisations for nuclear-licensed sites are already Environment Agency practice and will continue to be so.

4.1.5 Enforceability

The Environment Agency's principle of enforceability means that limits have to be set in relation to something that a) is unequivocally within the operator's

control and b) can be measured. Part II of this report shows how this principle is met.

4.1.6 Proportionality

The proportionality principle is that 'the remedy should fit the task and there should only be regulation when it is needed' [DETR 2000 and *Better Regulation Guide* 1998]. This principle is applied throughout the setting of numerical discharge limits (see sections 7 and 8 in Part II of this report). In addition, a check is made to ensure that any expenditure incurred by the operator, while complying with proposed numerical limits, would not be grossly disproportionate to the benefits associated with the proposed limits (see section 9 in Part II).

4.1.7 Targeting

The targeting principle is that 'regulation should be focused on the problem and side effects minimised' [DETR 2000 and *Better Regulation Guide* 1998]. This is achieved by using the BPEO and BPM approaches (see section 3), and in practical aspects of limit setting (see Part II).

4.1.8 Consistency

Consistency implies predictability and that people should know where they stand [DETR 2000 and *Better Regulation Guide* 1998]. The publication and use of the guidance developed in this report is intended to promote and maintain consistency in limit setting.

4.2 Specific principles

This section describes the more specific principles given in the draft Statutory Guidance [DETR 2000] for use in setting numerical discharge limits. Implementing these principles is dealt with in Part II of this report.

4.2.1 Site and plant limits

This principle is that discharge limits should be set both in terms of the amounts of radioactivity that may be discharged from the site as a whole, and in terms of the discharges from individual plants and/or groups of plants.

4.2.2 Criteria for selecting radionuclides

The draft Statutory Guidance states that, as a minimum, discharge limits should be set for those radionuclides and/or groups of radionuclides that:

- are significant in terms of radiological impact for humans and non-human species, including radionuclides that may be taken up in food;
- are significant in terms of the quantity of radioactivity discharged, whether or not they are significant for radiological impact;
- have long radioactive half-lives, that may persist and/or accumulate in the environment and that may contribute significantly to collective dose;
- are good indicators of plant performance and process control;
- provide for effective regulatory control and enforcement.

4.2.3 Minimising headroom

This principle is that discharge limits should be set so as to minimise the 'headroom' between the actual levels of discharge expected during normal operation and the limits themselves.

4.2.4 Capping at design level

The draft Statutory Guidance states that discharges from new plant should be capped at the levels for which approval is first given for full operation. It also states that caps may be reconsidered in the light of operating experience. In addition, operators should be required to make a full case for any increase in limits for existing plant, particularly where the original limits were not radionuclide specific.

4.2.5 Notification levels

The draft Statutory Guidance states that the Environment Agency may set notification levels for each plant, associated with the need to demonstrate BPM. The notification levels should be for key radionuclides, chosen, with regard to their radiological significance and sensitivity, as indicators of the performance of operational processes and techniques to reduce discharges.

4.3 Other issues

4.3.1 Monitoring

Authorisations have attached requirements for monitoring both discharges and the environment (see section 5). The draft Statutory Guidance [DETR 2000] states that monitoring requirements for discharges should be framed so as to allow discharges from each plant, or from appropriate sources on large plant, to be identified separately, rather than only covering discharges aggregated over the site.

Discharge monitoring is considered when setting discharge limits and levels, in order that appropriate, practical controls can be set on plants and groups of plants (see Part II). The Environment Agency will include improvement requirements in authorisations where these are necessary to achieve better discharge monitoring – including better disaggregation of contributions from several plants. The BSS Direction means that the Environment Agency has to require operators to have appropriately qualified experts involved in discharge and environmental monitoring. This is achieved via the monitoring requirements in authorisation conditions (see section 5).

4.3.2 Record keeping

Reporting and record keeping requirements are specified in authorisations (see section 5), in accordance with the principles in the draft Statutory Guidance.

4.3.3 R&D

It is Environment Agency practice to include in authorisation conditions any requirements for R&D on particular topics, often within specified timescales (see section 5). This practice will continue, thus meeting the principle in the draft

Statutory Guidance. R&D may be required on discharge abatement, improvements to the processes that give rise to waste (in order to reduce arisings), and other topics, including monitoring techniques and equipment.

5. Features of template authorisation

The Environment Agency has developed a 'template authorisation' that is used when revising authorisations at nuclear-licensed sites, and that will be used if new authorisations are required at such sites (for example, due to a change in licensee). The template authorisation covers solid waste transfers and disposals, as well as discharges of liquid and airborne effluents. The main features relevant to effluent discharges are outlined below.

5.1 General limitations and conditions

The general limitations and conditions are given in Schedule 1 of the template authorisation, and include the following:

5.1.1 Disposal

This section of the template authorisation requires the operator to use BPM to:

- minimise the activity of all waste that will require disposal under the authorisation;
- minimise the activity of airborne and liquid waste disposed *of via* discharge to the environment;
- dispose of radioactive waste at times, and in a form and manner, which minimise the radiological impacts on the environment and members of the public.

The operator is also required to maintain systems and equipment in good repair, and to check the effectiveness of systems, equipment and procedures at an appropriate frequency.

5.1.2 Management

The operator is required to have a management system, organisational structure and resources that achieve compliance with the limitations and conditions of the authorisation. There are specific requirements for:

- written arrangements specifying how the operator will achieve compliance with each limitation and condition in the authorisation;
- provision to consult with suitable Radiation Protection Advisers (RPAs, see IRR 99);
- written environmental operating rules and operating instructions;
- adequate supervision, by suitably qualified persons, of both the disposal of radioactive waste and the operation and maintenance of systems and equipment.

5.1.3 Sampling, measurements, tests, surveys and calculations

The operator is required to take samples and conduct measurements, tests, surveys analyses and calculations to determine compliance with the limitations and conditions of the authorisation. The operator is also required to use BPM when carrying out these activities, unless other particular means are specified in the authorisation. Since environmental measurements and assessments are also required, the operator is obliged to maintain in good repair the systems and equipment necessary for the monitoring and measurements required to determine compliance with the limitations and conditions of the authorisation. Likewise, the operator must ensure the condition of the systems and equipment necessary to measure and assess the exposure of members of the public and radioactive contamination of the environment. There must also be appropriate criteria for acceptance into service of such systems, equipment and procedures, and systems and equipment must be regularly calibrated and checked.

5.1.4 Records

The general record keeping requirements are:

- to make and retain records sufficient to demonstrate whether the limitations and conditions in the authorisation are complied with;
- to retain records made in accordance with any previous authorisation issued to the operator for the premises;
- to retain records made by any previous operator.

There are specific requirements for monthly records of the type of waste and disposal route, the total activity of each radionuclide or group of radionuclides in the waste disposed, and the date and time on which, or period during which, the disposal took place.

5.1.5 Provision of information

The operator is required to inform the Environment Agency, in writing, of the techniques they employ to determine the activity of radioactive waste disposals, prior to the first disposal of waste under the authorisation. The operator must also inform the Environment Agency, in advance, of any modifications to these techniques. Finally, the operator must inform the Environment Agency, without delay, if there is reason to believe that any disposal of radioactive waste is occurring, has occurred, or might occur, which does not comply with the limitations and conditions of the authorisation, and must subsequently report the circumstances in writing as soon as practicable.

5.2 Waste types and disposal routes

Schedule 2 of the template authorisation specifies the types of waste that may be disposed and the disposal routes which may be used. The table in the schedule will specify, for example, that gaseous and aqueous waste may be discharged to the environment.

5.3 Discharge limits and conditions

Schedules 3 and 4 of the template authorisation give the limitations and conditions relating to the disposal of airborne and liquid effluents by discharge to the environment. They contain the authorised airborne discharge outlets and authorised liquid discharge systems, together with the annual discharge limits. Quarterly notification levels and weekly advisory levels are also typically included (see also Part II of this report). In addition, Schedules 3 and 4 specify any particular means by which measurements of the activity of discharges are to be made in order to demonstrate compliance with limits.

Schedule 5 of the template authorisation contains the limitations and conditions relating to disposal of radioactive waste by incineration on the premises. The schedule specifies the types of waste that may be incinerated, the authorised incineration units and the limits on activities of radionuclides, or groups of radionuclides, in waste incinerated over a specified time period (typically a month).

5.4 Improvements and additional information requirements

The final schedule in the template authorisation specifies improvements and additional information requirements that the operator must complete before given dates. The standard requirements are that the operator shall provide the Environment Agency with a:

- a comprehensive review of whether the current disposal routes continue to represent the BPEO for waste disposal from the site, together with a programme for carrying out any necessary changes identified by the review;
- comprehensive review of national and international developments in best practice for minimising all waste disposals, together with a strategy for achieving reductions in discharges;
- a comprehensive review of the means used both to assess the activity of radionuclides in disposals and to determine compliance with the authorisation. The review must include consideration of national and international developments in best practice.

There may also be a requirement to establish and carry out an R&D programme in support of these elements, and to supply the Environment Agency with details of the programme and its results. Any other requirements for improvements and information are also included, if needed, for the site in question.

Part II – Methodology for setting discharge limits

6. Limit setting in the regulatory and authorisation contexts

Figure 1 shows, schematically, those parts of the Environment Agency's regulatory activities at nuclear-licensed sites that are most closely related to setting limits on radioactive discharges to the environment. Not all of the activities in Figure 1 are relevant to all reviews of authorisations at all nuclear-licensed sites, and the level of detail in each activity will vary from one site to another. Although Figure 1 is framed in terms of reviewing an existing authorisation, the same basic activities would be carried out where a new authorisation was to be issued at an existing site[4].

During the enforcement of the site operator's current authorisation under RSA, the Environment Agency's nuclear regulators carry out a number of activities whose results feed into the review of that authorisation. These activities are as follows (see Figure 1):

- a review of the operator's BPEO studies;
- a review of the operator's BPM studies;
- a review of the operator's discharge-related R&D;
- BPM audits of plant performance;
- a review of the operator's plans for plant closures, for the construction and operation of new plant, and for new operations at existing plant (such as decommissioning or dealing with legacy wastes);
- a review of the operator's waste management strategy.

The results of these activities are used, *inter alia*, to inform the decisions on major improvement schemes relating to discharges.

Although the general aim is to review authorisations about every four years, the timing on reviewing an authorisation for a specific site depends largely on the anticipated timing of major changes that will influence discharges at the site – particularly those plant closures and improvement schemes that will lead to discharge reductions. It would be wasteful of Environment Agency resources to devote a great deal of effort to an authorisation review where there is little

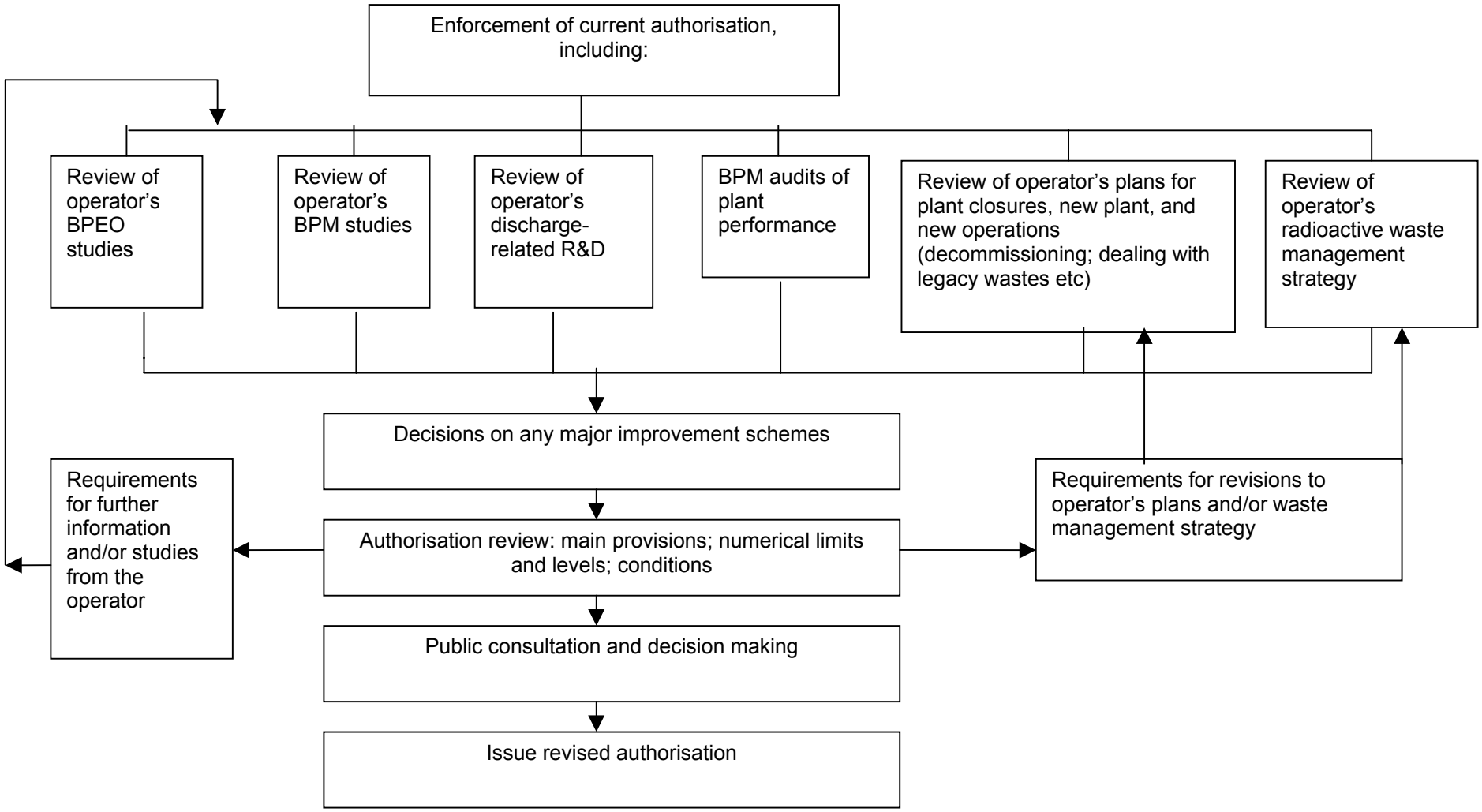
[4] In the past, a new authorisation had to be issued if there was a change of licensee at an existing nuclear site. The Nuclear Sites and Radioactive Substances Act (currently in draft form, see DTI [2003]) will introduce a procedure for transferring an authorisation from one nuclear site licensee to another.

practical prospect of any real reduction in discharges, or other improvement in radioactive waste management, at a site. However, not every review will involve major changes to discharge limits. The main outcome of a review could be inclusion, in the authorisation, of a requirement to implement an improvement scheme; the next review would then change the discharge limits to reflect the implementation of that scheme.

The review of an authorisation covers all the limitations and conditions set out in it, of which the numerical limits form one important part. The limitations and conditions in the revised authorisation are based on those detailed in the template authorisation (see section 5). The review process may well involve the Environment Agency requiring the operator to provide further information, and perhaps specific studies. It may also lead to a requirement for the operator to revise plans for plant and operations on the site, and/or the radioactive waste management strategy for the site. In general, the review process proceeds iteratively: the Environment Agency reviews what the operator provides, requests further or revised information, and reviews the operator's responses (see Figure 1).

The final steps in the authorisation review are public consultation and decision making. As input to the public consultation, the Environment Agency publishes: the operator's submissions (both the initial submissions and any subsequent additions or revisions); the Environment Agency reviews of these; the initial proposal for a revised authorisation; the reasoning and assessments connected with the proposal. The Environment Agency publishes the responses to the consultation, and the evaluation of these, in a 'decision document' that contains the proposed authorisation. This is sent to environment and health ministers, who then have an opportunity to intervene. The process of public consultation and decision making can also be iterative if the initial proposal has to be revised, to any significant extent, in the light of public or ministerial views.

Figure 1 Schematic flowchart of Environment Agency regulatory activities



7. Setting Annual Limits

The recommended methodology for setting annual discharge limits is one that closely follows that developed for, and used in, the 2001 review of the BNFL Sellafield authorisation. Given that it proved appropriate for that complex site, the Environment Agency wishes to apply it at other sites, with simplifications where necessary. The methodology is shown schematically in the flowchart in Figure 2, and each of the method's steps is discussed below. While this discussion relates to the review of an existing authorisation, the same basic steps would apply when issuing a new authorisation at an existing site.

7.1 Initial input

The three basic types of initial input to setting annual discharge limits are:

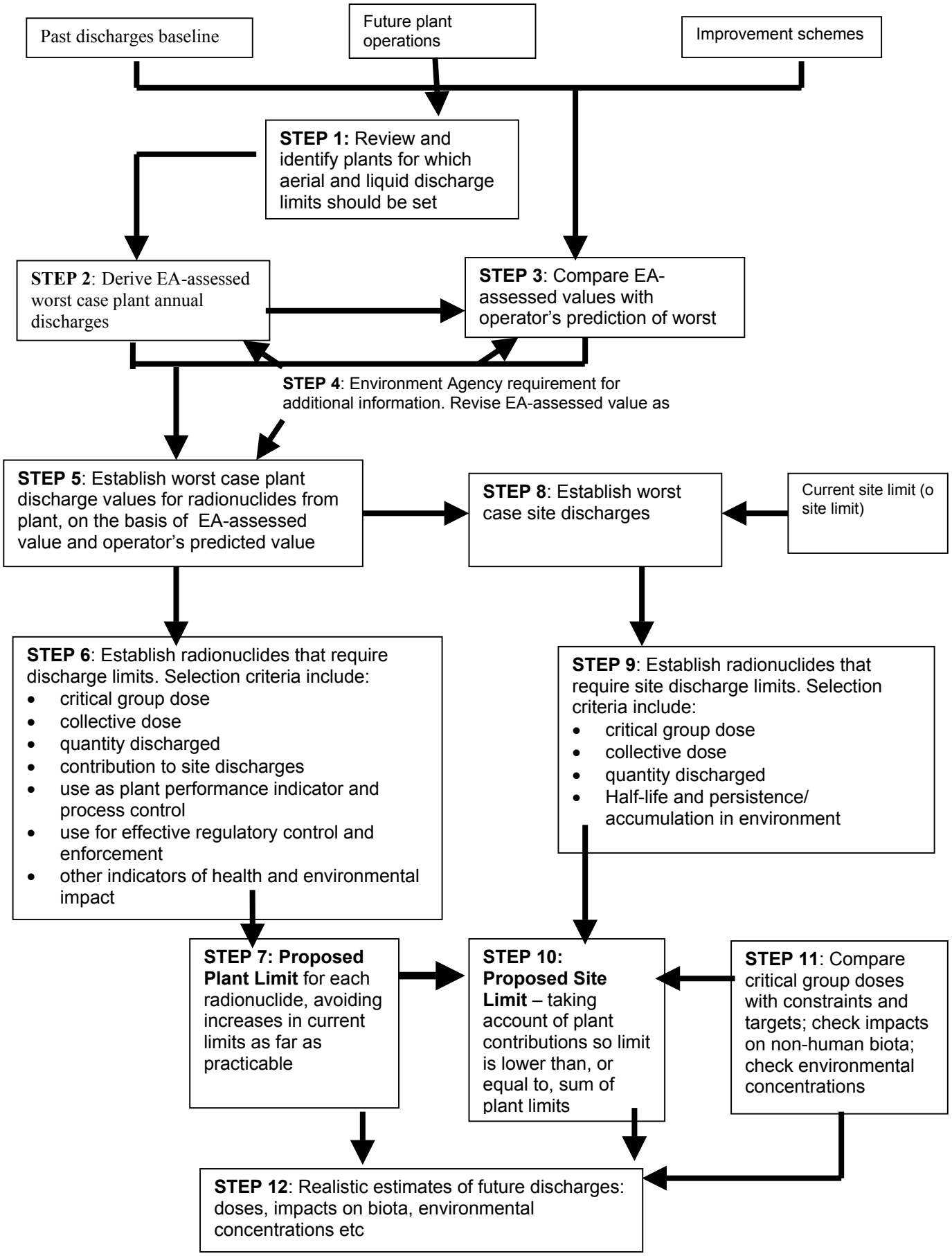
- the baseline of past plant and site discharges;
- future plant operations:
  - continued operation of existing plant
  - plant closures
  - new plants
  - dealing with legacy wastes
  - decommissioning of plant at the end of its operational life;
- improvement schemes that will be implemented during the period of the authorisation.

Post-operational clean out (POCO) and the care and maintenance of plant that is not in use are regarded as part of continued operations if the plant is to be used again. Otherwise they are regarded as part of decommissioning.

There can also be input to limit setting from R&D carried out since the last review of an authorisation. Such R&D may have been carried out by the operator as a result of requirements in the existing authorisation (see section 5), or carried out by the Environment Agency or other bodies (as in the case, for example, of R&D on the environmental behaviour of radionuclides). In addition, there are often issues that arise during regulatory activities that must be addressed when setting limits (see section 6).

Appendix A provides a checklist of information to be requested from the operator as input to setting limits.

Figure 2 Flowchart illustrating methodology for setting annual discharge limits



7.2 Step 1: Plant identification

The first step consists of reviewing all plants on the site that contribute to discharges and identifying those plants, and groups of plants, for which aerial and liquid discharge limits should be set. The requirement is to segregate discharges as far as reasonably practicable, so as to increase the effectiveness of controls and provide transparency for operators, regulators and the public (see section 4.2.1). The practicalities of discharge monitoring are taken into account during plant identification.

It is not necessary to be able to monitor activities in effluents actually discharged in order to set an enforceable plant discharge limit. Instead, it is possible to require the operator to monitor effluent activities prior to treatment, and to calculate the amounts discharged using factors that account for the efficiency of specific treatment techniques. In such cases, the Environment Agency will require the operator to substantiate the accuracy of the factors used. This approach can be particularly important in situations where the effluents from several plants enter one common treatment plant. In such situations, the Environment Agency may satisfy the principle of segregating discharges by setting limits for each of the major plants that produce effluents, and requiring the operator(s) to monitor these effluents at source. Limits will also be set for the relevant effluent treatment plant, such that contributions from plants that do not have their own discharge limits are controlled adequately.

The number of plants, or groups of plants, for which it is appropriate to set limits varies from one site to another. For example, at operating reactor sites the whole site can often be treated as one plant, while at a complex site like Sellafield there is a need to set limits for several plants and groups. At many sites the plants and groups for which limits are set will be different for aerial and liquid discharges.

For some plants it is more appropriate to exercise control by setting limits on parameters related to discharges than on discharges themselves (eg limits on feedstock at incinerators). Since the discharges from such plants should be considered when setting site limits (see sections 7.11 and 7.12), it is, therefore, necessary to establish worst case discharges from them (see sections 7.2-7.6), even though there will be no discharge limits actually set for them.

At decommissioning sites it can be appropriate to consider campaigns that will make major contributions to overall site discharges, putting less emphasis on individual plants (see also section 8.3). For simplicity, in what follows, the term ‘plant’ is used to mean any individual plant, group of plants or campaign, for which the Environment Agency wishes to set discharge or discharge-related limits. In addition, given that aerial discharge limits are often set for various stacks on a site, ‘plant’ will also be used here to mean the plant or groups of plants served by the stack for which the limit is to be set.

This first step may include identifying monitoring-related improvements, as well as any R&D to be addressed in authorisation conditions (see section 5). Such improvements and R&D may relate to improving equipment and techniques, or to plant or process changes which allow better discharge monitoring.

7.3 Step 2: Initial estimates of worst case plant discharges

Step 2 consists of deriving Environment Agency-assessed worst case plant annual discharges, using past discharge data (where relevant) and by taking account of improvement schemes and the operator's plans for future operations. This step uses a BPM approach, within the context of substantiated operator need (see section 3.1).

The procedure for estimating worst case annual plant discharges (WCPD) is as represented by the following equation:

$$WCPD = (1.5 \times D \times T \times A \times B) + C + L + N - I$$

where:

- 1.5 is an Environment Agency-established factor which relates 'worst case' to average discharges and takes account of the requirement to minimise headroom (see section 4.2.3).

- D is the representative average 12-month plant discharge. The average is calculated from the monthly discharges over about the last five years (or the time since the last review of the authorisation if this is shorter). The average excludes discharges due to faulty operation of plant and those that pre-date any changes to monitoring arrangements, plant operation or abatement measures during the review period. The average includes discharges arising from minor unplanned events (eg boiler tube failures at Magnox reactors).

- T is a factor, which allows for any future increases in throughput, power output etc relative to the review period.

- A is a factor, which allows for plant ageing – that is, for increases in discharges which result from changes within the plant as it ages that cannot be remedied or controlled by the operator (such as corrosion of the graphite core of a reactor, which leads to increased liquid and aerial discharges of carbon-14).

- B is a factor, which allows for other future changes that are beyond the control of the operator. For example, in a reprocessing plant, these would include the need to deal with higher burn-up or shorter-cooled fuel; at a dockyard, the need to deal with wastes from a new class of submarines.

- C is an allowance for decommissioning work beyond that carried out in the review period (and included in D).

- L is an allowance for dealing with legacy wastes, beyond those dealt with in the review period (and included in D). Although it is preferable to include all the discharges from dealing with legacy wastes in L, this is not always possible (see also section 7.14).

- N is an allowance for new plant.

- I is the reduction in discharges expected as a result of introducing improvement schemes before the new authorisation comes into force.

For new plant, worst case discharges are based on the operator's flow sheet data. It is usually appropriate to take the worst case to be a factor of 2 times the best estimate. Benchmarking against similar plant elsewhere is carried out where possible, to provide input to establishing worst case discharges.

The derivation of the factors T, A and B, the allowances C, L and N, and the reduction I requires judgements by Environment Agency nuclear regulators, using all the available information and their experience.

7.4 Step 3: Comparison with operator's predictions

The third step is to compare the Environment Agency-assessed values with the operator's predictions of worst case plant annual discharges. Areas where there are significant differences are highlighted and considered in Step 4.

7.5 Step 4: Requiring further information

Where Step 3 reveals significant differences between Environment Agency values and operator's predictions, Step 4 is to require further information from the operator, and, if necessary, to revise the assessed values. This is an iterative process, and there may be several sets of Environment Agency requests to the operator before it is satisfied on the relevant technical issues – particularly on those relating to BPM. The process may also lead operators to revise their estimates of either future discharges, or of some of the factors that may influence them.

7.6 Step 5: Establishing worst case plant discharges

The fifth step consists of establishing worst case discharge values for each radionuclide discharged from each major plant or group of plants on the site, on the basis of the agency-assessed value and the operator's predicted value. The established worst case

plant discharge (EWCPD) is generally taken to be the lower of the two. However, if the Environment Agency-assessed value is the lower, it is sensible to check it against the maximum annual past discharges. This is because, in some circumstances, the generalised methodology used to obtain the assessed value can underestimate variations which occur during normal operations. If the underestimation is substantial, the EWCPD can be taken to be a value that is slightly greater than the maximum annual past discharge (for example 120 per cent of the maximum figure).

7.7 Step 6: Choosing radionuclides for plant limits

Step 6 is to establish the radionuclides, or groups of radionuclides, for which it is necessary to propose discharge limits for each plant or group of plants. In some cases it may be necessary to propose limits for radionuclides when they occur in particular chemical forms (eg organically bound tritium). The criteria used in this step are described below.

7.7.1 Types of criteria for selecting radionuclides

The criteria used to select the radionuclides cover:

- critical group dose
- collective dose
- quantity discharged
- contribution to site discharges
- usefulness as a plant performance indicator and for process control
- usefulness for regulatory control and enforcement
- limits of detection.

These criteria are described in the following sections. In practice, radionuclides, or groups of radionuclides, that satisfy one or more of these criteria are selected.

When selecting radionuclides, and groups of radionuclides, it is important to bear in mind associations between radionuclides. There may be several radionuclides that arise together, and that together, or separately, satisfy one or more criteria. In such cases, it is only necessary to limit discharges of one of the radionuclides in order to achieve the required degree of control. A particular case is when one, more easily measured radionuclide can be used as a surrogate for another, less easily measured, radionuclide. When surrogate radionuclides are used, it is important that the contributions from those radionuclides for which they are surrogates are included when assessing the impacts of discharges (see sections 7.12.-7.14).

Limits on the broad groups of radionuclides ‘total alpha’ and ‘total beta’ are frequently set in addition to limits on specific radionuclides. This is because such limits provide effective controls without very detailed discharge monitoring. It is necessary to be clear about which radionuclides are included in such groups for a particular plant, so that this

information can be used in setting site limits and estimating the impacts of discharges at these limits (see sections 7.11 and 7.12).

Note that, where *groups* of radionuclides are limited, the limit is necessarily 'referential', in the sense that it relates to a particular method of measurement which must be specified in the authorisation. By contrast, for *individual* radionuclides, where limits are interpreted as being absolute, the authorisation can place a requirement on the operator to use BPM to assess the discharges. For this reason, where a choice is possible, it may be better to place an *absolute* limit on a single radionuclide within the group than to set a *referential* limit for the group as a whole.

7.7.2 Critical group dose criterion

A plant limit is proposed if the critical group dose from the EWCPD is greater than 1 μSv per year. The 1 μSv criterion is derived by taking 10 per cent of 10 μSv, which is the level given in the BSS Directive as that below which authorisation need not be required. The figure of 10 per cent is in turn based on a maximum of 10-20 radionuclides making significant contributions to critical group doses from discharges at complex plants. The dose assessment methodology used in conjunction with this criterion is given in *Principles for the Assessment of Public Doses* [Environment Agency *et al* 2002].

7.7.3 Collective dose criterion

A plant limit is proposed if, over 500 years, the collective dose from the EWCPD to the world population is greater than 0.1 man-sievert per year of discharge. The 0.1 man-sievert criterion is derived by taking 10 per cent of 1 man-sievert, which is the level given in the BSS Directive as that below which authorisation need not be required. The figure of 10 per cent is based on a maximum of 10 radionuclides making significant contributions to collective doses from discharges at complex plants. The dose assessment methodology used in conjunction with this criterion is given in *Principles for the Assessment of Public Doses* [Environment Agency *et al* 2002].

7.7.4 Quantity discharged

A plant aerial limit is proposed if the aerial EWCPD exceeds 1 TBq per year, and a plant liquid limit is proposed if the liquid EWCPD to the marine environment exceeds 1 TBq per year. These criteria are based on current discharge limits at major nuclear plants, and may not be appropriate for smaller plants.

7.7.5 Contribution to site discharges

This criterion is that a plant limit is proposed where the EWCPD exceeds 50 per cent of the current site limit.

7.7.6 Plant performance indication and process control

Radionuclides are selected for plant limits if their discharges are good indicators of plant performance or process control. Judgements on what constitutes a good indicator are specific to the types of plant and process.

7.7.7 Regulatory control and enforcement

Radionuclides are selected for plant limits if this is felt to be necessary for effective regulatory control and enforcement. This criterion is a very general one, and, so as not to breach the principle of proportionality (see section 4.1.6), care is required to avoid setting limits for too many radionuclides.

7.7.8 Limits of detection

It is not useful to set plant discharge limits that are below the limits of detection (LoD) of either existing monitoring arrangements or any improved arrangements to be introduced during the time before the next authorisation review. If, for other reasons, it would be desirable, in the future, to set a plant limit for a radionuclide that is below its current LoD, then it is necessary to identify monitoring-related improvements and R&D to be addressed by the operator. These improvements and R&D can be specified in authorisation conditions (see section 5), and may relate to better equipment and techniques, or to plant or process changes that allow better discharge monitoring.

7.8 Step 7: Plant annual discharge limits

Step 7 is to propose plant annual discharge limits for each radionuclide for each plant or plant group, taking into account the requirements to minimise headroom, to provide the operator with a margin and to avoid increases in current limits as far as practicable. The limits are for a rolling 12-month period (see section 5).

In general, the plant annual discharge limit is taken to be equal to the EWCPD, because minimising headroom whilst providing the operator with a margin will have already been taken into account in deriving the EWCPD (see sections 7.3-7.6). Assuming that a) there are to be no unavoidable upward trends associated with continuing plant operation (eg due to plant ageing), and b) that no major improvement schemes have been introduced since the last review of the discharge limits, then capping at the current plant discharge limit may be appropriate where there are to be no significant increases in either decommissioning work or dealing with legacy wastes, if there. Caps for new plant may be varied upwards or downwards in the light of operating experience (see section 8.1).

7.9 Step 8: Worst case site discharges

The eighth step is to calculate the site's worst case discharges as the sum of the established worst case plant discharges. Again, assuming that a) there are to be no unavoidable upward trends associated with continuing plant operation (eg due to plant ageing), and b) that no major improvement schemes have been introduced since the last review of the site limits, then capping at the current site discharge limit may be appropriate where there are to be no significant increases in either decommissioning work or dealing with legacy wastes.

7.10 Step 9: Choosing radionuclides for site limits

This step consists of establishing the radionuclides (or the groups of radionuclides) for which it is necessary to propose site discharge limits. The criteria used are discussed below.

7.10.1 Types of criteria for selecting radionuclides

The criteria used to select the radionuclides cover:

- critical group dose
- collective dose
- quantity discharged
- usefulness for plant performance/process control or regulatory control and enforcement
- persistence/accumulation in the environment
- other impacts on the environment and human health.

The first four of these are as described in section 7.7; the other two are described below.

7.10.2 Persistence/accumulation in the environment

A radionuclide is proposed for a site annual discharge limit if both its radioactive half-life is greater than 10 years and its concentration factor in any environmental material is greater than 1000. Radionuclides with lower half-lives will not persist in the environment, while those with lower concentration factors do not accumulate significantly in environmental materials. The materials considered in applying this criterion include the tissues of living organisms, as well as water, soil and sediments. The concentration factors used are those employed in assessing the impacts of discharges (see sections 7.12-7.14).

7.10.3 Other impacts on the environment and human health

One criterion under this heading concerns possible jeopardy to communities of non-human biota (see sections 2.2.5 and 3.4.4). While there are, as yet, no ‘dose limits’ for non-human biota, it is, nevertheless, possible to assess whether jeopardy to communities is likely. Methods for assessing potential radiological impacts on biota are outlined in a joint Environment Agency and English Nature publication [Copplestone *et al* 2001].

A further criterion is the possible prejudice of legitimate uses of the land (including surface water and groundwater) or of the sea (see section 2.2.6). To apply this criterion, radionuclides are proposed for site limits if their concentrations in foods could approach or exceed CFILs (see section 3.4.5). Other radionuclide concentration levels used in applying the criterion may include reference levels for drinking water [WHO 1993], and clearance levels for solid materials [Article 31 Expert Group 2000].

The existence of uncertainties in the estimation of human health and environmental impacts may also be considered as a criterion. This is connected with the principle of precautionary action (see section 2.2.8).

7.11 Step 10: Site annual discharge limits

Site annual discharge limits are the primary means for regulatory control of impacts on the public and the environment. They are derived using factors which take account of the contributions of plants to site discharges. The limits are for a rolling 12-month period.

The proposed site annual discharge limit is calculated as:

site limit = F x sum of EWCPDs

where:

F = 1 if any EWCPD is greater than 80 per cent of the sum of EWCPDs
F = 0.9 if any EWCPD is 50-80 per cent of the sum of EWCPDs
F = 0.8 if all EWCPDs are less than 50 per cent of the sum of EWCPDs

This approach is used because it is very unlikely that all the plants contributing to site discharges will experience worst case discharges at the same time. Rather, it takes account of whether one or several plants dominate discharges. All EWCPDs should be included in the sum, regardless of whether discharge limits are set for that plant or whether it has discharge-related limits. The result of this approach is usually that the proposed site annual discharge limits are less than, or equal to, the sum of the plant annual discharge limits.

7.12 Step 11: Impact of discharges at annual limits

This step, which relates to discharges at site limits, consists of: comparing critical group doses with constraints and targets; checking that there will be no adverse impacts on non-human biota; checking that CFILs will not be exceeded; checking that environmental concentrations will not prejudice legitimate uses of the land or the sea.

The methodology for assessing critical group doses is given in *Principles for the Assessment of Public Doses* [Environment Agency *et al* 2002]. Methods for assessing potential radiological impacts on biota are outlined in Copplestone *et al* [2001]. The use of appropriate spreadsheets is recommended, to avoid running complex models many times. The spreadsheets would, for example, relate critical group doses to unit discharges.

It is desirable to provide information about uncertainties in impacts. This may be achieved by carrying out sensitivity analyses with models, or by including appropriate semi-quantitative or qualitative discussion.

7.13 Step 12: Impacts of future discharges

Step 12 consists of providing realistic estimates both for future site discharges (assuming limits are set at the proposed levels), and for the corresponding critical group and collective doses, impacts on biota and environmental levels. A comparison is also made with past discharges and with any targets that have been set. The step is required because operators rarely work up to limits. Also, in the past, it has been possible for actual discharges to increase even though limits stay the same (or are reduced).

7.14 Contributions due to operations, decommissioning and dealing with legacy wastes

While limits are set, and impacts are estimated, taking into account all contributions to plant and site discharges, it is, nevertheless, necessary to separate the contributions of operations, decommissioning and dealing with legacy wastes, such that they can be easily understood. This is done by producing appropriate materials (descriptions and tables), which include, if necessary, approximations where it is not possible to easily separate these contributions.

7.15 Annual limits that vary over the authorisation period

All of the methodology outlined above assumes that plant and site annual limits are to remain the same over the period until the next authorisation review (about four years). However, there can be circumstances in which this is not desirable. For example, if:

- it is anticipated that there will be relatively large discharge reductions during the authorisation period, as a result of plant closures or the introduction of improvement schemes;
- it is anticipated that there will be changes in throughput or power output that will increase discharges (see also section 8.2);
- there will be short-term operations that require above average discharges (see also section 8.3).

In such cases it could be more appropriate to set annual plant and site limits that vary from year to year, rather than setting annual limits for the whole authorisation period that are based on the maximum necessary. There is also another approach for setting plant limits, which could be particularly appropriate if the timing of plant changes is uncertain at the time of the authorisation review. This alternative approach involves changing the annual plant limits over the course of the authorisation period, and can be achieved by means of a variation to the authorisation, without prior consultation with ministers. (Annual site limits cannot be changed without prior ministerial consultation.)

7.16 Applying the methodology

Appendix B describes a number of illustrative examples of the application of the methodology for setting discharge limits. In these examples, annual effluent discharge limits are considered for three nuclear-licensed sites at which authorisations have either been reviewed and revised recently, or will soon be reviewed. The three sites are: Devonport Royal Dockyard, Heysham Power Station and Hinkley Point A Power Station. The annual discharge limits that might be proposed – were the methodology applied – are derived, and compared to the limits in the current and/or proposed authorisations. While these are not fully worked examples of the methodology, they do illustrate some features of its application.

The examples presented in Appendix B suggest that the methodology would lead to annual discharge limits that keep headroom to extremely low levels. This is due to the recommendation in the methodology to use, as the starting point for setting limits, a value of 1.5 times the average of discharges over recent years. In the recent reviews of the authorisations considered in the appendix, the Environment Agency has tended to focus on maximum past discharges, and to allow an operating margin on these. At least in these examples, this gives higher limits than the procedure in sections 7.3-7.11.

7.17 Other inputs to setting discharge limits

The examples in Appendix B reveal some of the difficulties that can arise in applying, to additional sites, the limit setting methodology based on one particular site. There will also be instances where discharge data are either unavailable or else not available in the form required for use in the equation detailed in section 7.3. In other instances discharge data may not be considered to be reliable (for example, because they are at the limits of detection). For these reasons, there is a need for flexibility in using the methodology outlined above. The limits derived using the methodology should, in general, be viewed only as a starting point. The Environment Agency will also need take into account other factors when proposing discharge limits and in reaching final decisions on discharge limits (see also section 6).

8. Other limits and levels

8.1 Discharge caps for new plant

The draft Statutory Guidance requires that annual limits for new plant are capped at the levels set when approval is first given for full operation, while allowing for reconsideration in the light of operating experience [DETR 2000]. The approach described in section 7 above allows for caps to be set. Reconsideration of caps is dealt with in BPM determinations, and is likely to be particularly necessary for novel plants. In all cases, the Environment Agency will require that operators make a full case for discharge increases.

8.2 Limits related to throughput and power output

There is a need to consider whether it is appropriate to set additional plant annual limits that are directly related to plant throughput, power output, or other parameters, rather than basing limits on fixed estimates of these. The advantage of such limits is that they can achieve greater regulatory control, for example, where it is doubtful that relatively new plant will achieve design targets within the authorisation period. These limits are plant specific, and are set so that limits for less than full operation are lower than annual limits derived by the approach described in section 7.

8.3 Limits for particular operations

It is also necessary to consider whether to set limits for particular operations that will not last for the whole authorisation period, but that will entail discharges higher than those pertaining to the rest of the authorisation period. An example would be a campaign to deal with particular legacy wastes or a decommissioning operation that will last for about a year. The advantages of such limits are that they could provide greater regulatory control and greater transparency.

8.4 Short-term plant limits and advisory levels

Limits for periods of less than one year are needed to ensure that effective management controls are used on plants. Where there could be conflicts between operating a plant safely and meeting a limit, advisory levels, rather than limits, are set. While the Environment Agency is standardising, as far as possible, on weekly plant limits and advisory levels, limits and levels for shorter or longer periods (days, months) may be used where these are more appropriate.

The criterion used in deciding whether short-term limits and levels are needed is the critical group dose, taking into account any possible fluctuations in dose per unit

discharge as a result of, for example, weather conditions, or seasonal agricultural and fishing practices. For aerial discharges, weekly limits (or advisory levels) are proposed if it seems that the dose to the critical group from a short-term discharge could exceed 20 μSv. For liquid discharges, the criterion for proposing a short-term limit or level is 10 μSv to the critical group.

Weekly limits are typically taken to be one-tenth of the relevant annual plant limit. A check is made to ensure that annual critical group doses from releases at the weekly limits will not exceed 0.3 mSv per year, using the dose calculation methodology for short-term releases described by the Environment Agency *et al* [2002].

8.5 Discharges to sewer

Limits for discharges to sewer may be specified in terms of radionuclide concentrations, rather than total discharges, where it is not reasonably practicable for the operator to estimate and report annual discharges. In other cases sewer discharges are dealt with in the same way as plant discharges for limit setting purposes. The Environment Agency *et al* [2002] describe the dose calculation methodology for discharges to sewer.

8.6 Notification levels

Notification levels are associated with BPM and are set for radionuclides that are radiologically significant and are sensitive as indicators of plant and process control. While it is now usual for the Environment Agency to set notification levels for a rolling three-month period, levels for shorter periods may also be used. In any case where a notification level is exceeded, the operator is required to produce a retrospective BPM demonstration.

The simplest procedure is to set notification levels *pro rata* to annual limits. For example, quarterly (three-month) notification levels for plants and for the site would be set at 25 per cent of the relevant annual discharge limits. In some circumstances notification levels may be set above the *pro rata* annual levels, but they should always be below the levels that would correspond to foreseeable unplanned events occurring during the relevant period.

8.7 Fugitive emissions

‘Fugitive emissions’ are discharges that occur (mainly to the atmosphere) through routes other than the principal engineered effluent discharge routes. Sources of fugitive emissions include: non-engineered ventilation points on plants; some fuel storage ponds; areas of contaminated land (from which activity may be released to air by resuspension). These emissions can be detected by environmental monitoring, such as air sampling.

In general, sources of fugitive emissions should be subjected to regulatory control by designating them as ‘approved places’ and setting annual discharge limits for them in the same way that plant annual discharge limits are set. Fugitive emissions will then need to be included when setting site annual limits (see section 7.11). The preferred method for demonstrating compliance with annual limits for fugitive emissions is through environmental monitoring as close to the source as is practicable. Fugitive emissions should also be considered in BPM audits, with a view to their reduction.

9. Economic and resource impact assessment

Compliance with proposed numerical limits on discharges may require the operator to incur additional financial expenditure and extra staff effort. An economic and resource impact assessment is needed so that the Environment Agency can check that this additional expenditure is not grossly disproportionate to the benefits associated with the proposed limits [DEFRA 2002b]. The assessment for the proposed numerical limits may be carried out as a standalone exercise, or as part of an overall assessment of the impact, on the operator, of the proposed authorisation. (An overall assessment would include, for example, the costs of any improvement schemes or studies of such schemes that conditions in the authorisation require the operator to carry out.)

The complexity of the assessment will depend on the anticipated scale of the impact. The first step is for the Environment Agency to request the operator to provide an order of magnitude estimate of the additional costs that the operator would incur if the proposed numerical limits were incorporated in the revised authorisation. The Environment Agency will then decide whether more detailed estimates are needed, and whether it needs to employ independent consultants to gather these estimates from the operator, or to scrutinise these estimates when the operator has produced them. The expenditure estimates, and the appraisal of them, will usually be included in the documents issued for public consultation on the proposed authorisation.

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List of abbreviations

AGR	Advanced Gas-Cooled Reactor
ALARA	as low as reasonably achievable
ALARP	as low as reasonably practicable
BAT	best available technique
BNFL	British Nuclear Fuels
BPEO	best practicable environmental option
BPM	best practicable means
BSL	basic safety limit
BSS	EU basic safety standards
BSS Directive	European Basic Safety Standards Directive 96/29
BSS Direction	Radioactive Substances (Basic Safety Standards) Direction 2000
CFIL	European Community food intervention level
DEFRA	Department for Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
DoE	Department of the Environment
DTI	Department of Trade and Industry
EA 95	Environment Act 1995
EU	European Union
EWCPD	established worst case plant discharge
HSE	Health and Safety Executive
IRR 99	Ionising Radiation Regulations 1999
LMA	Liabilities Managing Authority (now NDA)
LoD	limit of detection
MoD	Ministry of Defence
NDA	Nuclear Decommissioning Authority
OSPAR	Oslo and Paris Convention for the protection of the marine environment of the north-east Atlantic
POCO	post-operational clean out
PPC	Pollution Prevention and Control regime
R&D	research and development
RIFE	Radioactivity in Food and the Environment
RPA	Radiation Protection Advisor
RSA 93	Radioactive Substances Act 1993
RSA authorisation	authorisation made under RSA 93
SAPs	HSE safety assessment principles
SEPA	Scottish Environment Protection Agency
SSSI	Site of Special Scientific Interest
WCPD	worst case plant discharge

Appendix A: Information to be obtained from the operator when setting discharge limits

A1 Introduction

This appendix lists the information typically required by the Environment Agency to undertake a full re-examination of an operator's authorisation (or authorisations) under RSA 93. The information required is listed below under a number of convenient headings. The operator is required to provide large data sets (eg past discharge data, environmental monitoring data) in electronic format, where possible, in addition to a paper copy. This is required to save time and effort, and to minimise transcription errors.

A2 Past aerial and liquid discharges

- Data are required for the period from the start of the current authorisation until the end of the calendar year prior to the authorisation review.
- Monthly discharge data should be provided.
- Data should be provided for all major facilities. (These facilities would be listed in the Environment Agency's request for information and may be placed in priority order.)
- Data should be provided on all measurements/assessments (ie limited radionuclides and any other radionuclides measured) made at the accountancy points (including specific radionuclides and total alpha/beta).
- Measurement data should be provided, where available, for the discharges from each approved place. In all other cases an estimate/assessment of the annual activity discharged from each approved place should be provided. (On the basis of this information the Environment Agency will determine whether more detailed information is required.)
- Where specific facility data are not available this deficiency should be identified and information should be provided from the next downstream monitoring point, which should also be identified.
- An explanation of the reason for past discharge trends is required. This should explain the reasons for step changes in discharges, progressive reductions or increases, and any atypical discharges due to events or incidents outside of the normal operating envelope of the plant.
- For all major facilities, the operator should provide estimates of all discharges of individual radionuclides which are (or are suspected to be) discharged, but which are not measured.

A3 Future aerial and liquid discharges

- Best estimates and worst case estimates of future discharges should be provided up to a specified date. (This date is site specific but would typically be a few years beyond the period for which the next authorisation is to remain current.) These estimates should be given by radionuclide (and/or radionuclide group). Totals should be provided for the entire site, for each of the current authorisation schedules, and for each major facility.
- Data should be on the basis of 12-month rolling discharges.
- The operator's site discharge strategy for contributing to the objectives of the national discharge strategy, and the requirement for a progressive reduction in discharges throughout the period to 2020, should be provided.
- Justification that the impact of proposed discharges (superimposed on the artificial radioactivity already in the environment around the site) would not prejudice uses of the land or the sea (eg farming, fishing and recreation) should be provided.
- Should increases in discharges be proposed, a detailed justification should be provided as to why these are necessary.

A4 Other potential sources of radioactive waste

- A statement is required that the information the operator provides on discharges is comprehensive and accurate, and that the operator is not aware of any other potential sources of radioactive discharges or discharges which could be significantly underestimated or overestimated. Monitoring data should be provided to support this statement, where available.
- If the operator has reason to believe that radioactive waste is being discharged *via* routes other than those in the current authorisation(s), the Environment Agency should be informed immediately.

A5 Segregation of discharges

- Historic and future discharge information for each of the major facilities should be related to one or more of the main activities carried out on the site (eg power generation; decommissioning of redundant plant; dealing with legacy wastes). Where more than one activity is attributed to the discharges, details of the work required to monitor the activities separately should be provided. This should include indicative costs and time scales to undertake the work.
- This information should cover liquid and aerial discharges.

A6 Plans for future plant

- Details of any plans to build future plants that may require authorisation to discharge radioactive waste should be supplied. Where possible the scope of information

provided should be consistent with the requirements of a new application for an RSA authorisation.

A7 Best Practicable Environmental Option (BPEO)

- BPEO assessment(s) of the waste management practice should be provided for each major plant/facility, process, or business area on site, as appropriate. Where appropriate, the assessment(s) should take full account of the implications of waste management practice downstream of the facility or business area (eg for liquid discharges this would be the downstream effluent treatment plant). The assessment(s) should evaluate the existing waste management practices and alternative options on the basis of factors such as radiological impacts on the public and workers, the environmental impacts, cost and social implications. Top level options should be considered – such as building new facilities or making use of other existing facilities – in addition to modifications to the existing process.
- Should it transpire that any of the current waste management practices assessed are not the BPEO, the BPEO should be identified and information provided on the work required to implement the BPEO. This should include costs and time scales.
- Should further information be required to complete the BPEO assessment, the operator should state what this is.

A8 Best Practicable Means (BPM)

- BPM assessments should be undertaken for the major discharge streams and routes from all major plants/facilities.
- The BPM assessments should consider process optimisation, management control procedures relevant to waste minimisation, and the abatement technology employed. Factors including cost effectiveness, technological status, operational safety and social factors, and environmental impacts/risks should be taken into account.
- Should it transpire that any of the current disposal routes assessed do not currently employ the BPM, the BPM should be stated and information provided on the work required to implement the BPM. This should include costs and time scales.
- Should further information be required to complete a BPM assessment, the operator should state what this is.

A9 Future improvement plans

- An assessment is required of the mode of operation of plants, and whether it would be practicable to implement changes that would lead to a reduction in the volume and activity of waste created, minimise the volume and activity of discharges/disposals, and/or reduce radiation doses to members of the public. (These considerations are expected to form part of the BPEO/BPM assessments.)
- All future plans that will lead to a reduction in the volume and activity of waste created, minimise the volume and activity of discharges/disposals, and/or reduce

radiation doses to members of the public should be identified. These plans should include proposed fitting of abatement, optimisation of processes and management control initiatives. The scope of these plans should be made clear (ie which facility or facilities they relate to, and indicative costs and time scales should be provided).
- Estimates should be provided for radiation exposure of workers and the risk of accidents as a result of measures taken to reduce the volume and activity of waste created, minimise the volume and activity of discharges/disposals, and/or reduce radiation doses to members of the public.

A10 Design limits

- Where appropriate the original discharge/disposal design limits for all major facilities should be provided.

A11 R&D Programme

- Details of the current research and development programme should be provided. These should cover: options for abatement of discharges; sampling and monitoring techniques for the measurement of discharges, disposals and environmental concentrations; understanding the behaviour of radionuclides in plant processes and within the environment. A programme for future research and development should be given. This should include costs and time scales.
- The key findings of the past R&D programme should be summarised by research area and by radionuclides (and/or group of radionuclides).
- The strategy behind the development of past and future programmes should be given.

A12 Radiological assessment

A12.1 Man

- The operator should assess the radiological impact on man of past, current and future disposals (as liquids or gases) from the site, and direct radiation from the site by calculating:
  - Annual individual doses to candidate critical groups from all past discharges using the results of the most recent environmental monitoring and direct radiation from the site;
  - Annual individual doses in the 50^{th} year of release to candidate critical groups for current discharges (at current limits, and at the levels in the most recent discharge returns) and direct radiation from the site;
  - Collective doses to regional, national and international populations truncated at 500 y per year of release for current discharges (at current limits and at the levels in most recent discharge returns);

    - Annual individual doses in the 50th year of release to candidate critical groups for future discharges (at requested limits) and direct radiation from the site;
    - Collective doses to regional, national and international populations truncated at 500 y per year of release for future discharges (at requested limits).

- Individual doses arising from each significant radionuclide discharged in liquid effluents should be calculated for:
    - Liquid releases from the major discharge streams which feed to the discharge pipeline and the sewer;
    - Total liquid releases of radioactivity to the aquatic environment.

- Individual doses from each significant radionuclide discharged in gaseous effluents should be calculated for:
    - Gaseous releases from each of the stacks under schedules in the current authorisation;
    - Gaseous releases from approved places discharges;
    - Total aerial releases from all stacks.

- Collective doses arising from radioactive discharges in liquid effluents should be calculated for:
    - Total liquid releases of radioactivity to the aquatic environment;

- Collective doses arising from radioactive discharges in gaseous effluents should be calculated for:
    - Total gaseous releases from all the stacks and approved places.

1.1.1 A12.2 Environmental impact

- The operator should provide details of the current programmes and findings of research on the behaviour, in the environment, of radionuclides discharged from the site, with the objective of improving the understanding of the effects on the sustainability of ecosystems and communities of non-human species.
- An outline of the proposed future research and development programme should be provided. This should include costs and time scales.
- Estimates of the significant environmental concentrations resulting from the site's discharges should be provided. This assessment should cover as wide a range of environmental matrices as possible (both non-human species and inorganic matrices). This should provide details of the maximum concentrations resulting from past discharges, and clearly show the expected contribution from future discharges (the assessment should consider best estimates and worst case future discharges).
- An assessment of the radiological impact of the aerial and liquid discharges on non-human species should be provided. This should include an assessment of the potential wider ecological impact of radioactive discharges with particular reference to

specific conservation sites such as Sites of Special Scientific Interest (SSSIs), Special Areas of Conservation and Special Protection Areas.

A13 Operational parameters

- Details of past and future work programmes relevant to radioactive discharges should be provided. Where possible, past information should be provided on a monthly basis and the discharge stream to which it relates should be identified. This should include best estimate and worst case information for the future site work programmes.
- Information relevant to the setting of short-term limits should be provided.

A14 Environmental monitoring

- The operator should highlight any planned changes to the environmental monitoring programmes associated with the liquid and aerial discharge authorisations. The costs and time scales associated with these changes should be provided.
- Electronic data from the statutory environmental programmes and internal operator environmental programmes should be provided. Where possible, data going back further in time than the start of the current authorisation should be provided to allow longer term trends to be assessed.

A15 Analytical techniques

- The operator should provide information on the radiochemical analytical techniques employed to assess discharges and disposals, and to undertake environmental monitoring. This information should consider whether the techniques and the detection limits achieved represent best practice. It should also consider consistency across the site. In circumstances where it is concluded that best practice is not being employed, recommendations should be provided for the measures required to meet best practice. Indicative time scales and costs for implementing these measures should be provided.

- In particular, the following should be considered:
  - the range of radionuclides analysed;
  - suitability of detection limits employed;
  - the frequency of analyses.

A16 Monitoring, sample collection and sample storage methodologies

- The operator should provide information on the monitoring, sampling, collection and storage methodologies, and sample retention times employed to assess discharges

and to undertake environmental monitoring. This information should consider whether the sampling, collection and storage techniques represent best practice. It should also consider consistency across the site. In circumstances where it is concluded that best practice is not being employed, recommendations should be provided for the measures required to meet best practice. Indicative time scales and costs for these measures to be implemented should be provided.

A17 Maintenance and inspection

- The operator should provide information on the maintenance and inspection of all systems associated with the discharge or disposal of radioactive waste. This should include all compliance monitoring equipment. Details of the past inspection and maintenance programmes, and an assessment of whether they represent best practice should be included. The past inspection and maintenance records should be evaluated, and any common faults/failures recognised. In circumstances where it is concluded that best practice is not being employed, recommendations should be provided for the measures required to meet best practice. Indicative time scales and costs for these measures to be implemented should also be provided. Similarly, if common faults/failures are recognised, recommendations for rectifying these issues should be given, along with indicative time scales and costs for implementing these recommendations.

A18 Records

- The operator should provide details of the availability of all records associated with the authorisations. These should list the nature of each set of records, the manner in which they are made, the place in which they are kept, their retention period and the system(s) used to record entries and any changes to the records.

A19 Incidents

- The operator should provide a review of past environmental events, incidents and breaches of the authorisations (including notification levels) during the period from the start of the existing authorisation to the end of the calendar year prior to this current authorisation review. This should consider all incidents which are directly or indirectly associated with the RSA authorisations, and include near misses. A root-cause analysis, and details of the way in which recommendations are closed out should be included.

A20 Management systems

- The operator should provide details of management arrangements and controls for ensuring that discharges are as low as reasonably achievable. These should include details of the top-down organisational management structure and should identify

specific management levels with responsibilities for environmental discharge/disposal control.

- Details of the change control procedures used by the operator for plant modifications and staff/management changes should be provided.
- Details should be provided on how the operator ensures the competence of all staff involved in work that is directly or indirectly related to the RSA authorisations. In addition, the operator should provide details of the resources applied to the staffing and management of matters that are directly related to the RSA authorisations.

Appendix B: Illustrative examples of the applying the methodology to setting limits

B1. Introduction

The purpose of this appendix is to illustrate the application of the methodology for limit setting given in Part II of the main text. This is done by considering annual effluent discharge limits for three nuclear-licensed sites for which authorisations have been reviewed and revised recently or will soon be reviewed. The three sites are: Devonport Royal Dockyard (operated for the Ministry of Defence by DML), Heysham Power Station (British Energy) and Hinkley Point A Power Station (operated by Magnox Electric). For the convenience of readers, section B2 below summarises the limit setting methodology. The following sections derive the annual discharge limits that might be proposed if the methodology is applied, and compare these to the limits in the current and/or proposed authorisations.

B2. Summary of methodology

The methodology given in the main text for obtaining annual discharge limits involves deriving worst case annual plant discharges (WCPD) of each radionuclide from each major plant (or group of plants) on the site (see section 7). Limits for the site are obtained by summing these established worst case plant discharges (EWCPD).

In section 7 the procedure for estimating the worst case discharge of a radionuclide from a plant is represented by the following equation:

$$WCPD = (1.5 \times D \times T \times A \times B) + C + L + N - I$$

where:

1.5 is an Environment Agency-established factor which relates ‘worst case’ to average discharges and takes account of the requirement to minimise headroom.

D is the representative average 12-month plant discharge. The average is calculated from the monthly discharges over about the last five years (or the time since the last review of the authorisation if this is shorter). The average excludes discharges due to faulty operation of plant and those that pre-date any changes to monitoring arrangements, plant operation or abatement measures during the review period. The average includes discharges arising from minor unplanned events (eg boiler tube failures at Magnox reactors).

T is a factor which allows for any future increases in throughput, power output etc relative to the review period.

A is a factor which allows for plant ageing – that is, for increases in discharges which result from changes within the plant as it ages that cannot be remedied or controlled by the operator (such as corrosion of the graphite core of a reactor, which leads to increased liquid and aerial discharges of carbon-14).

B is a factor which allows for other future changes that are beyond the control of the operator. For example, in a reprocessing plant, these would include the need to deal with higher burn-up or shorter-cooled fuel; at a dockyard, the need to deal with wastes from a new class of submarines).

C is an allowance for decommissioning work beyond that carried out in the review period (and included in D).

L is an allowance for dealing with legacy wastes, beyond those dealt with in the review period (and included in D). Although it is preferable to include all the discharges from dealing with legacy wastes in L, this is not always possible.

N is an allowance for new plant.

I is the reduction in discharges expected as a result of introducing improvement schemes before the new authorisation comes into force.

The main text states that, for new plant, worst case discharges are to be based on the operator's flow sheet data, and that taking the worst case to be a factor of 2 times the best estimate is usually appropriate. Benchmarking against similar plant elsewhere should be carried out where possible, to provide input to establishing worst case discharges.

In an actual authorisation review, the WCPD would be compared to the operator's predictions, and there would be iterations between the Environment Agency and the operator about any differences. These could result in changes to the agency's WCPD prior to derivation of the EWCPD. The subsequent steps in the methodology would normally involve the selection, according to various criteria, of radionuclides that require plant and site discharge limits. However, in the examples described in this appendix these steps are omitted. Instead it is assumed that limits would be set for those radionuclides, or groups of radionuclides, for which there are limits in the current and/or proposed authorisation.

As outlined in section 7 above, the proposed plant limits are based directly on the EWCPD. The proposed site annual discharge limit for each selected radionuclide is calculated as:

site limit = F x sum of EWCPDs

where:

F = 1 if any EWCPD is greater than 80 per cent of the sum of EWCPDs
F = 0.9 if any EWCPD is 50-80 per cent of the sum of EWCPDs
F = 0.8 if all EWCPDs are less than 50 per cent of the sum of EWCPDs.

B3. Devonport Royal Dockyard

1.1.2 B3.1 Context

The authorisation for discharges from Devonport Royal Dockyard was reviewed in 2000-2002, and a new authorisation is now in force. DML, the operators of the site, applied to the Environment Agency in May 2000 for variations in the five existing authorisations for the site under RSA 93. The variations were required because the Ministry of Defence (MoD) had decided that all future refitting and refuelling of Vanguard class nuclear-powered submarines would take place at Devonport, in addition to those of Trafalgar class submarines.

DML applied for increases in the discharge limits for some radionuclides, to allow for the maximum levels of radioactive waste they expected to generate. While tritium discharges to the Hamoaze have increased in recent years, discharges of cobalt-60 have decreased. As cobalt-60 is more radioactively significant, DML estimated that the radiological significance of their operations would not change. The Environment Agency took the opportunity to consolidate the five Devonport authorisations into one comprehensive authorisation, using its template authorisation for nuclear sites (see section 5 of the main text above).

After several rounds of consultation with stakeholders and the public, the revised proposals were submitted to the Secretary of State for the Environment, Food and Rural Affairs and to the Secretary of State for Health, for them to decide whether to exercise their powers of direction. After requesting further information, the Ministers announced, in February 2002, that a public inquiry was not required, and they did not propose to exercise their powers of ‘call-in’. The proposals the Environment Agency had submitted were accepted, and a new authorisation was issued.

The data required to assess the Devonport authorisation against the methodology outlined above were obtained from a number of sources (Environment Agency [2001a and 2001b], FSA [1999-2001] and DEFRA [2002]).

B3.2 Plants and radionuclides for which annual limits are set

For the purposes of setting authorised limits on airborne and aqueous radioactive discharges, the Environment Agency treats the nuclear-licensed site operated by DML as one 'plant'. While the contributions from all the relevant plant and operations on the site are taken into account when setting annual site limits, no separate limits are set for individual plants or operations.

The radionuclides for which annual limits are now set are as follows:

Airborne discharges: tritium, carbon-14, argon-41, β/γ particulates

Aqueous discharges: tritium, carbon-14, cobalt-60, other radionuclides

The limits on carbon-14 and argon-41 in airborne discharges are new, and were requested by DML in its submission for the authorisation review because of the increased discharges expected from Vanguard class submarines. The limit on carbon-14 in liquid discharges is also new, and was introduced by the Environment Agency during the recent review of the authorisation. Prior to the current authorisation, carbon-14 was included in 'other radionuclides'.

B3.3 Derivation of site limits

1.1.3 B3.3.1 Airborne discharges

There is insufficient information in the available documentation to enable limits on airborne discharges to be derived using the methodology described in section 7 above. In particular, there is no information in either the Environment Agency's explanatory document, or its decision document, about the relative contributions of operations on Trafalgar and Vanguard class submarines to annual discharges [Environment Agency 2001a and 2001b].

For tritium, carbon-14 and argon-41 the agency set limits that were equal to DML's estimates of the 'maximum necessary' discharges, without any of the additional margin requested by DML. In all three cases, discharges are expected to be dominated by Vanguard submarines. It is design and operational features of those submarines that largely determine discharges, and these are beyond the control of both DML and the Environment Agency. For β/γ particulates the limit was left unchanged from that in the previous authorisation. The Environment Agency stated that the limit is set at a low level and provides an operational margin. Table B1 shows: the limits in the previous authorisation; those requested by DML; those set by the Environment Agency in the authorisation that came into force in 2002.

Table B1 Limits on airborne discharges at Devonport Dockyard

Radionuclide (units of limit)	Limit in previous authorisation	Limit requested by DML	Limit set by the Agency in 2002
tritium (GBq/y)	1	5	4
carbon-14 (GBq/y)	-	45	43
argon-41 (GBq/y)	-	15	15
β/γ particulates (MBq/y)	0.3	0.3	0.3

B3.3.2 Aqueous discharges

Tritium

Data from the RIFE reports indicate that the average annual tritium discharge in the late 1990s was about 107 GBq. The Environment Agency's explanatory document states that the maximum amount of tritium discharged over a rolling 12-month period in recent years was 112 GBq from refitting Trafalgar class submarines [Environment Agency 2001a]. DML estimated that, at most, 429 GBq would be discharged each year from refitting Vanguard class submarines, and that in future the maximum discharges from refitting Trafalgar class submarines would increase to 200 GBq per year as a result of a change in MoD operating practices. Using these values in the equation detailed in section B2 would give:

WCPD = (1.5 x 107) + (200 – 112) + 429 = 678

The site limit for liquid discharges of tritium would thus be 680 GBq using the methodology described in this report. The limit set by the Environment Agency was slightly higher at 700 GBq, and was said to allow for operational variations [Environment Agency 2001a].

Cobalt-60

In the late 1990s the maximum liquid discharge of cobalt-60 in a rolling 12-month period was below 0.2 GBq per year and the average was about 0.1 GBq. DML assessments gave an annual discharge of 0.2 GBq per year from the refitting of Vanguard class submarines [Environment Agency 2001a]. Using the equation in section B2:

WCPD = (1.5 x 0.1) + 0.2 = 0.4

The site limit for liquid discharges of cobalt-60 would thus be 0.4 GBq using the methodology described above. The Environment Agency set a limit of 0.8 GBq, which was rather less than the limit requested by DML of 2 GBq.

Carbon-14 and 'other radionuclides'

Carbon-14 was previously included with ‘other radionuclides’. While no estimates of past discharges of this radionuclide were available, the maximum discharge of ‘other radionuclides’ (including carbon-14), in a rolling 12-month period, was 0.44 GBq. DML estimated a carbon-14 discharge of 1.35 GBq per year from refitting Vanguard class submarines and a ‘baseline’ discharge of 0.058 GBq of ‘other radionuclides’ [Environment Agency 2001a]. The Environment Agency set a limit of 1.7 GBq for carbon-14 and a limit of 0.3 GBq for ‘other radionuclides’ (excluding carbon-14, tritium and cobalt-60). There is insufficient information in the various references to derive limits using the methodology in section 7 of the main text.

Summary comparison

Table B2 shows the liquid discharge limits in: the previous authorisation; those requested by DML; those set by the Environment Agency in the authorisation that came into force in 2002; those that would be derived using the methodology described in section 7 of this report.

Table B2 Limits on aqueous discharges at Devonport Dockyard (GBq/y)

Radionuclide	Limit in previous authorisation	Limit requested by DML	Limit set by the Agency in 2002	Limit from method described here
tritium	120	800	700	680
cobalt-60	6	2	0.8	0.4
carbon-14	-	-	1.7	-
others	1	2	0.3	-

B4. Heysham Power Station

1.1.4 B4.1 Context

The Environment Agency has not yet begun to review the existing authorisations for the Heysham site (or any of the British Energy sites) and therefore British Energy has not yet requested new discharge limits. For this worked example the limits that would be obtained using the methodology described above are compared with those in the existing authorisations. Discharge data have been obtained from the Environment Agency inspector for Heysham, and from FSA [1999-2001] reports.

B4.2 Plants and radionuclides for which annual limits are set

The Heysham site is approximately five miles west of Lancaster, on the Lancashire coast, and consists of two power stations – Heysham 1 and Heysham 2 – with a total of four AGRs. There are separate discharge authorisations for Heysham 1 and Heysham 2, each being treated as a separate site. There are no limits set for the individual plants on each site.

The radionuclides for which annual limits are set for each site are as follows:

Airborne discharges: beta particulates, tritium, carbon-14, sulphur-35, argon-41, iodine-131

Aqueous discharges: tritium, sulphur-35, cobalt-60, other radionuclides

B4.3 Derivation of site limits

Table B3 shows airborne and aqueous discharges from Heysham 1 and Heysham 2 for the years 1999, 2000 and 2001. Also shown in the table are the average discharges for the three years and the WCPD calculated simply as 1.5 times the average discharge (see section B2). The last column in Table B3 shows the annual discharge limits that

would be obtained by rounding the WCPD values to one significant figure. This procedure is used in this example to illustrate how it could be used to provide a baseline for considering possible new limits. The WCPD values in Table B3 are adjusted upwards in cases where the rounded value would be less than the actual discharge in any of the three years. This is done because it seems more straightforward than the suggestion, in section 7.6, to use about 1.2 times the maximum past discharge in cases where 1.5 times the average is less than the maximum.

In Table B4 the limits derived in Table B3 are compared to those in the current authorisations. This reveals that the limits derived from the WCPD are all lower than the current limits, by factors ranging from about two (eg tritium liquid discharges) to about one hundred (eg airborne discharges of beta particulates). The comparison in Table B4 suggests that the limits in the current authorisation allow British Energy generous operating margins for some radionuclides, and that in some cases the 'headroom' in the current limits is too great.

On the other hand some of the limits derived from the WCPD might provide too small an operating margin. In order to check this, Table B5 shows the discharges in 1999, 2000 and 2001 as percentages of the limits derived from the WCPD. For most radionuclides in most of the years the discharges are more than 40 per cent but less than 75 per cent of the WCPD-derived limits. The main exceptions to this are aqueous discharges of sulphur-35 in 2001.

Since April 2001 COS injection has increased the sulphur-35 discharges at both Heysham 1 and Heysham 2. COS injection improves the heat transfer across the steam generator system by delaying build-up and removing carbon deposits. British Energy argue that the impact of greater sulphur-35 discharges is more than offset by the lower emissions of carbon dioxide (because less electricity has to be generated using fossil fuels). The present trend is for further increases in sulphur-35 discharges, and the Environment Agency would need to decide whether this should continue, and to reflect its decision on this in setting discharge limits.

Table B3 Recent discharges and WCPD at Heysham

Site; form of discharge; radionuclide		**Recent Annual Discharges (TBq)**				**WCPD (TBq)**	**Limit from WCPD (TBq)**
		1999	*2000*	*2001*	*Average*		
Heysham 1							
Aqueous	H-3	3.95E+02	4.41E+02	3.99E+02	4.12E+02	6.18E+02	6.00E+02
	S-35	1.43E-01	1.21E-01	1.79E-01	1.48E-01	2.22E-01	2.00E-01
	Co-60	2.82E-04	1.05E-03	7.87E-04	7.06E-04	1.06E-03	2.00E-03

Site; form of discharge; radionuclide		Recent Annual Discharges (TBq)				WCPD (TBq)	Limit from WCPD (TBq)
		1999	*2000*	*2001*	*Average*		
	Other	1.16E-02	1.42E-02	2.11E-02	1.56E-02	2.35E-02	3.00E-02
Airborne	Beta	7.63E-06	7.66E-06	7.73E-06	7.67E-06	1.15E-05	1.00E-05
	H-3	1.12E+00	9.52E-01	1.39E+00	1.15E+00	1.73E+00	2.00E+00
	C-14	1.08E+00	1.38E+00	1.23E+00	1.23E+00	1.85E+00	2.00E+00
	S-35	1.88E-02	1.62E-02	2.12E-02	1.87E-02	2.81E-02	3.00E-02
	Ar-41	7.58E+00	1.41E+01	5.48E+00	9.05E+00	1.36E+01	2.00E+01
	I-131	1.09E-04	1.11E-04	1.11E-04	1.10E-04	1.66E-04	2.00E-04
Heysham 2							
Aqueous	H-3	2.55E+02	3.37E+02	3.30E+02	3.07E+02	4.61E+02	5.00E+02
	S-35	2.41E-02	3.75E-02	5.58E-02	3.91E-02	5.87E-02	6.00E-02
	Co-60	1.01E-03	3.66E-04	2.29E-04	5.35E-04	8.03E-04	2.00E-03
	Other	1.75E-02	1.48E-02	1.59E-02	1.61E-02	2.41E-02	3.00E-02
Airborne	Beta	8.73E-06	9.51E-06	1.11E-05	9.78E-06	1.47E-05	2.00E-05
	H-3	1.21E+00	1.06E+00	1.70E+00	1.32E+00	1.99E+00	2.00E+00
	C-14	1.09E+00	9.40E-01	1.15E+00	1.06E+00	1.59E+00	2.00E+00
	S-35	1.03E-02	1.96E-02	1.85E-02	1.61E-02	2.42E-02	3.00E-02
	Ar-41	1.30E+01	1.46E+01	1.76E+01	1.51E+01	2.26E+01	3.00E+01
	I-131	8.30E-05	3.67E-05	4.06E-05	5.34E-05	8.02E-05	1.00E-04

Table B4 Heysham discharge limits

Site; form of discharge; radionuclide		Current annual limit (TBq)	Limit derived from WCPD (TBq)	Ratio of current limit:WCPD limit
Heysham 1				
Aqueous	H-3	1.20E+03	6.00E+02	0.50
	S-35	2.80E+00	2.00E-01	0.07
	Co-60	3.00E-02	2.00E-03	0.07
	Other	3.00E-01	3.00E-02	0.10
Airborne	Beta	1.00E-03	1.00E-05	0.01
	H-3	6.00E+00	2.00E+00	0.33
	C-14	4.00E+00	2.00E+00	0.50
	S-35	1.20E-01	3.00E-02	0.25
	Ar-41	6.00E+01	2.00E+01	0.33
	I-131	5.00E-03	2.00E-04	0.04
Heysham 2				
Aqueous	H-3	1.20E+03	5.00E+02	0.42
	S-35	2.30E+00	6.00E-02	0.03
	Co-60	3.00E-02	2.00E-03	0.07
	Other	3.00E-01	3.00E-02	0.10
Airborne	Beta	1.00E-03	2.00E-05	0.02
	H-3	1.50E+01	2.00E+00	0.13
	C-14	3.00E+00	2.00E+00	0.67
	S-35	3.00E-01	3.00E-02	0.10
	Ar-41	8.50E+01	3.00E+01	0.35
	I-131	5.00E-03	1.00E-04	0.02

Table B5 Heysham discharges as percentages of limits

Site; form of discharge; radionuclide		Discharge as percentage of limit derived from WCPD		
		1999	*2000*	*2001*
Heysham 1				
Aqueous	H-3	66	74	67
	S-35	72	61	90
	Co-60	14	53	39
	Other	39	47	70
Airborne	Beta	76	77	77
	H-3	56	48	70
	C-14	54	69	62
	S-35	63	54	71
	Ar-41	38	71	27
	I-131	55	56	56
Heysham 2				
Aqueous	H-3	51	67	66
	S-35	40	63	93
	Co-60	51	18	11
	Other	58	49	53
Airborne	Beta	44	48	56
	H-3	61	53	85
	C-14	55	47	58
	S-35	34	65	62
	Ar-41	43	49	59
	I-131	83	37	41

B5. Hinkley Point A

1.1.5 B5.1 Context

In 1998 Hinkley Point A, as one of eight Magnox nuclear power stations that BNFL operate through Magnox Electric plc, applied to the Environment Agency for a revised authorisation to discharge radioactive wastes. This was in light of the expectation for all Magnox plants to cease operating by 2012, and to be operated until the end of their lives by BNFL rather than Magnox Electric. In August 2001 the Environment Agency published its recommendations and proposed decisions on the applications from BNFL. However, in June 2002, due to the expected proposal to establish a Liabilities

Management Authority (LMA)[5], BNFL withdrew its applications for new authorisations for the Magnox sites except for those at Trawsfynydd and Berkeley. The updated decision proposed that the existing authorisations for Magnox Electric be varied for the other sites. For Hinkley A, the changes either clarified the authorisation previously proposed for BNFL or brought it up to date. While minor aqueous discharges were now also incorporated, the annual limits were the same as those proposed in 2001.

Hinkley Point A was shut down in 2000 and has not been brought back into operational service since. The station is currently undergoing defuelling prior to decommissioning. Any fuel removed from the reactor and ponds will be transferred to Sellafield for reprocessing. Information and data for this example have been obtained from a number of sources, including Environment Agency [2001c, 2002a, 2002b and 2002c] and FSA [1999-2001] reports.

B5.2 Plants and radionuclides for which annual limits are set

The Environment Agency treats Hinkley A as one 'plant' for the purpose of setting annual discharge limits. The radionuclides for which annual limits were given in the previous authorisation were as follows:

Airborne discharges: tritium, carbon-14, sulphur-35, argon-41, beta particulates

Aqueous discharges: tritium, caesium-137, other radionuclides

Substantial airborne discharges of sulphur-35 and argon-41 only occur during reactor operation. During defuelling sulphur-35 discharges are very low, while discharges of argon-41 are essentially zero. BNFL stated in its application – and the Environment Agency accepted – that limits on these two radionuclides were not required now that Hinkley A was being defuelled.

B5.3 Derivation of site limits

1.1.6 B5.3.1 Airborne discharges

Historical airborne discharge data are of limited relevance in this example because they relate mainly to reactor operation, and airborne discharges are very different during defuelling and the initial stage of decommissioning. The equation given in section B2 is thus also of little relevance.

The Environment Agency used post-shutdown historical data for Hinkley A in its review of the authorisation, and also took into account experience at Trawsfynydd [Environment Agency 2001c]. For tritium, carbon-14 and beta particulates the proposed annual discharge limits were equal to those requested by BNFL. The Environment Agency

[5] Now to be known as the Nuclear Decommissioning Authority (NDA).

considered that these limits were ‘consistent with providing minimum headroom without prejudice to station decommissioning’. The limit proposed for beta particulates took into account the possibility that some decommissioning tasks might disturb particulate matter within the reactor gas circuit. Table B6 shows both the proposed limits and those in the existing authorisation (ie the one in force while Hinkley A was operating).

Table B6 Proposed and existing limits on Hinkley A airborne discharges

Radionuclide (units of limit)	Environment Agency Proposed Limit	Limit in existing authorisation
tritium (TBq/y)	1.5	25
carbon-14 (TBq/y)	0.6	4
sulphur-35 (GBq/y)	-	200
argon-41 (TBq/y)	-	4500
beta particulates (MBq/y)	150	1000

1.1.7 B5.3.2 Aqueous discharges

Data on recent past liquid discharges are relevant to the period during which the station is being defuelled because spent fuel continues to be stored for a time in the cooling ponds. Table B7 shows the discharges over the years 1998-2000 (the last three years for which data were available when the authorisation review began).

Table B7 Hinkley A Aqueous Discharges 1998-2000

Radionuclide	Annual Discharge (TBq)			
	2000	*1999*	*1998*	*Average*
tritium	1.09E+00	8.36E-01	7.08E-01	8.78E-01
Cs-137	1.30E-01	4.39E-01	4.93E-01	3.54E-01
other radionuclides	4.30E-01	2.73E-01	2.84E-01	3.29E-01

Tritium

Table B7 reveals that the average annual discharge of tritium is about 0.9 TBq. Applying the equation in section B2 with only the factor of 1.5 would give a WCPD, and hence a site limit, of 1.4 TBq per year. The Environment Agency proposed a limit of 1.8 TBq per year, based on the maximum discharge over a rolling 12-month period in the years 1993 to 2000 of 1.3 TBq. The Agency noted that tritium discharges had been rising since mid-1999, as a result of processing of greater volumes of cooling pond water, but that fuel transfers to Sellafield were expected to be expedited, leading to a fall in tritium discharges [Environment Agency 2001c]. BNFL had requested a limit of 2 TBq per year for tritium.

Caesium-137

Using the section B2 methodology in the same way as for tritium would give a site limit of 0.6 TBq per year (0.4 x 1.5) for caesium-137. The Environment Agency proposed a limit of 1 TBq. This took into account the maximum discharge over a rolling 12-month period of 0.6 TBq, the possibility that the cooling ponds might contain leaking fuel elements, and the use of caesium removal plant. BNFL had requested a limit of 1.5 TBq per year [Environment Agency 2001c].

Other radionuclides
The site limit for 'other radionuclides' derived using the factor of 1.5 in the methodology above would be 0.5 TBq per year. The Environment Agency proposed a limit of 0.7 TBq. This was less than the limit requested by BNFL of 1 TBq. It took into account the maximum discharge over a rolling 12-month period of about 0.4 TBq, the possibility that the cooling ponds might contain leaking fuel elements, and the use of caesium removal plant (which would take out caesium-134 and some other radionuclides).

Summary comparison
Table B8 shows the liquid discharge limits in the existing authorisation, those requested by BNFL, those proposed by the Environment Agency for the revised authorisation, and those that could be derived using the methodology in section 7 of the main text.

Table B8 Limits on Aqueous Discharges at Hinkley Point A (TBq/y)

Radionuclide	Limit in existing authorisation	Limit requested by BNFL	Limit proposed by Environment Agency	Limit from method described here
tritium	25	2	1.8	1.4
caesium-137	1.5	1.5	1	0.6
others	1	1	0.7	0.5

B6. Conclusions

It has not been possible, within the scope of this project, to carry out fully worked examples of the methodology recommended above for setting limits on discharges from nuclear-licensed sites. The examples in this appendix are somewhat limited, but do illustrate some features of applying the methodology.

The examples suggest that the methodology would lead to annual discharge limits that keep headroom to extremely low levels. This is because of the recommended procedure of using 1.5 times the average of discharges over recent years as the starting point for setting limits. In the recent reviews of authorisations considered in this appendix the Environment Agency has tended to focus on maximum past discharges, and to allow an operating margin on these. At least in these examples, this gives higher limits than the procedure described in section 7 of this report.

B7 References

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