Health Protection Agency

Dose Criteria for the Designation of Radioactively Contaminated Land

Advice from the Health Protection Agency

RCE-2

Dose Criteria for the Designation of Radioactively Contaminated Land

Documents of the Health Protection Agency
Radiation, Chemical and Environmental Hazards
March 2006

Contents

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Advice from the Health Protection Agency

Prepared by K R Smith, S F Mobbs and J R Cooper

The Department for Environment, Food and Rural Affairs (Defra) is currently developing regulations and associated statutory guidance for the identification and remediation of radioactively contaminated land. Defra asked the National Radiological Protection Board (NRPB) – now the Radiation Protection Division of the Health Protection Agency – for guidance on appropriate dose criteria to use for the definition of radioactively contaminated land under the new regulatory regime. This paper and the associated supporting paper (Mobbs et al, 2006, also published in this issue) form the Agency's response to that request.

The proposed regulations are intended to implement Articles 48 and 53 of the European Union's Basic Safety Standards Directive (BSS) (EC, 1996) in so far as they relate to radioactively contaminated land. The overall aim of the regulations is, as far as possible, to make land fit for current use. This is consistent with the general approach of Articles 48 and 53, which address intervention situations only. Remediation of radioactively contaminated land as part of site redevelopment is already covered under UK planning regulations.

Defra originally intended to base the definition of radioactively contaminated land, in respect of human beings, directly in terms of the resulting 'lasting exposure', a term introduced in Article 48 (Defra, Personal Communication, reproduced in Appendix A of Mobbs et al, 2006). Defra has since proposed basing the definition of radioactively contaminated land, in respect of human beings, in terms of the resulting 'harm', where 'harm' is, in turn, defined as 'lasting exposure' (Defra, 2005). In the context of the BSS, the Agency interprets the term 'lasting exposure' as referring to exposures that occur at a reasonably constant rate over a significant fraction of an individual's lifetime, ie some tens of years.

Article 53 relates to lasting exposures resulting from the 'after effects' of a radiological emergency or a past practice. In respect of radiological emergencies and consistent with the above definition of 'lasting exposure', the term 'after effects' is interpreted here as implying a timescale of at least a few years following an accident. Thus this advice should not be interpreted as applying in the short to medium term following an accident but may be relevant in the longer term.

The Agency considers that the designation of land as radioactively contaminated land should be based on a level of exposure at which it is appropriate that the site is investigated and remedial options are considered, but that intervention actions need not necessarily be undertaken as they may not be justified.

This paper from the Health Protection Agency reflects understanding and evaluation of the current scientific evidence as presented and referenced here.

Guidance from the International Commission on Radiological Protection in this area (ICRP, 1999) indicates that an annual dose* approaching 100 mSv will almost always justify intervention, whereas an annual dose approaching about 10 mSv may be used as a generic reference level below which intervention is not likely to be justifiable for some prolonged exposure situations. Existing NRPB guidance on radioactively contaminated land (NRPB, 1998) is that, in relation to intervention situations, if the projected lifetime dose from the contamination is estimated to exceed 1 Sv then measures to reduce this dose would almost certainly be justified (this corresponds to a dose rate in the region of 10 to 20 mSv y^{-1}).

The Agency considers, on the basis of the above and a review of additional international guidance and relevant national circumstances, that a dose of 10 mSv y^{-1} represents a level of exposure from radioactively contaminated land in the UK at which some form of intervention would normally be justified. This advice is clearly cautious in relation to ICRP guidance in this area.

The level of exposure at which detailed site investigation is appropriate and at which intervention should be *considered* is clearly below 10 mSv y^{-1}.

The Agency therefore considers that a level of 'lasting exposure' in the region of a few millisievert per year is appropriate for the designation of land as radioactively contaminated land. However, given the need for more straightforward advice appropriate for regulatory implementation, a single value of 3 mSv y^{-1} has been selected from the range. It should be stressed that an element of judgement was involved in arriving at this recommendation.

This advice is consistent with the UK Action Level for radon in homes of 200 Bq m^{-3} (NRPB, 1990), which corresponds to exposures in the region of 10 mSv y^{-1}.

The proposed regulations must also reflect the requirement to avoid deterministic effects; thus supplementary dose criteria are required for the skin and lens of the eye. Therefore, under situations where doses are being received or are likely to be received it is recommended that land should be defined as radioactively contaminated land if any of the following conditions is satisfied: the annual dose is greater than 3 mSv, the annual equivalent dose to the lens of the eye is greater than 15 mSv, or the annual equivalent dose to the skin is greater than 50 mSv.

The dose criteria apply to the incremental dose from the contamination (ie the total dose minus the natural background dose). For information, the average individual background radiation dose in the UK is around 2.2 mSv y^{-1}. Thus, an additional dose of 3 mSv y^{-1} would correspond to an increase of between two and three times the average annual dose in the UK. This should be viewed in the context of the fact that significant areas of the UK experience natural background exposures of two or three times the average.

The dose criteria refer to the mean dose in the appropriately defined critical group. They mark the dividing line between land which is not deemed to be radioactively contaminated and that which is defined as radioactively contaminated land. In circumstances where assessed doses are greater than the dose criteria, the land should be designated as radioactively contaminated land and intervention to reduce doses should be considered following a process of justification and optimisation but, depending

* Unless otherwise stated, the term 'dose' refers to 'effective dose' as defined by the ICRP (1991).

upon the outcome of such studies, not necessarily undertaken. Where assessed doses are less than the dose criteria, the land would not be categorised as radioactively contaminated land but this would not preclude the use of simple measures to reduce doses where appropriate.

A more detailed discussion of the derivation and application of the above advice is contained in the associated supporting paper.

Analogous criteria have also been developed for the definition of radioactively contaminated land under situations where the contamination is very heterogeneous (eg patchy or containing 'hot particles') and thus the probability of exposure may be much lower than unity. These are also addressed in the supporting paper.

References

EC (1996). Council Directive 96/29/Euratom of 13 May 1996 laying down the basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation. *Off J Eur Commun,* L159.

ICRP (1991). 1990 recommendations of the International Commission on Radiological Protection. ICRP Publication 60. *Ann ICRP*, **21**(1–3).

ICRP (1999). Protection of the public in situations of prolonged radiation exposure. ICRP Publication 82. *Ann ICRP*, **29**(1–2).

Mobbs SF, Smith KR and Cooper JR (2006). Dose criteria for the designation of radioactively contaminated land: support for advice from the Health Protection Agency. *Doc HPA: Radiat Chem Environ Hazards,* **RCE-2,** 5–20.

NRPB (1990). Human exposure to radon in homes. *Doc NRPB,* **1**(1), 17–32.

NRPB (1998). Radiological protection objectives for land contaminated with radionuclides. *Doc NRPB*, **9**(2), 1–12.

Dose Criteria for the Designation of Radioactively Contaminated Land:

Support for Advice from the Health Protection Agency

S F Mobbs, K R Smith and J R Cooper

Abstract

The Department for Environment, Food and Rural Affairs (Defra) is currently developing regulations and associated statutory guidance for the remediation of radioactively contaminated land. Defra asked the National Radiological Protection Board (NRPB) – now the Radiation Protection Division of the Health Protection Agency – for guidance on appropriate dose criteria to use for the definition of radioactively contaminated land under the new regulatory regime. This paper contains supplementary and explanatory material in support of the Agency's formal response to that request, which is also given in this document.

The Agency advises that a suitable dose criterion for the designation of radioactively contaminated land would be an effective dose of 3 mSv y^{-1} from the contamination. Other dose criteria are also given to protect against deterministic effects and to allow for exposures that are not certain to occur.

This paper from the Health Protection Agency reflects understanding and evaluation of the current scientific evidence as presented and referenced here.

1 Introduction

The Department for Environment, Food and Rural Affairs (Defra) is currently developing regulations and associated statutory guidance for the identification and remediation of radioactively contaminated land. Defra asked the National Radiological Protection Board (NRPB) – now the Radiation Protection Division of the Health Protection Agency – for guidance on appropriate dose criteria to use for the definition of radioactively contaminated land under the new regulatory regime, with respect to human beings. The letter from Defra requesting this advice is reproduced in Appendix A. This paper contains supplementary and explanatory material in support of the Agency's formal response to that request (HPA, 2006), which is also given in this document.

The proposed regulations are intended to implement the requirements of Articles 48 and 53 of the European Union's Basic Safety Standards Directive (BSS) (EC, 1996) in so far as they relate to radioactively contaminated land. In particular, Article 48 applies to cases of 'lasting exposure resulting from the after-effects of a radiological emergency or a past or old practice or work activity'. Articles 48 and 53 are given in Appendix B. The overall aim of the regulations is, as far as possible, to make land fit for current use by providing a system for the identification and remediation of land where contamination is causing lasting exposures to radiation, and where action is liable to be justified. Remediation of radioactively contaminated land as part of site redevelopment is already covered under UK planning regulations.

One of Defra's objectives for the regulatory development process is that, for consistency, the regulations and statutory guidance developed should mirror as closely as possible those already in force covering the identification and remediation of land contaminated with substances other than radionuclides. These are defined in Part IIA of the Environmental Protection Act 1990 (GB Parliament, 1990) – inserted by section 57 of the Environment Act 1995 (GB Parliament, 1995) – and are referred to as Part IIA in this paper. The objectives for the regime are to ensure the protection of human health and the wider environment.

Under the Part IIA regime land is defined as contaminated land when 'significant harm' is being caused or where there is a significant possibility of such harm being caused by substances in, on or under the land. Statutory guidance is given on what constitutes significant harm and the significant possibility of significant harm.

Defra originally intended to base the definition of radioactively contaminated land, in respect of human beings, directly in terms of the resulting 'lasting exposure', the term introduced in Article 48 of the BSS (Defra, Personal Communication, reproduced in Appendix A of this paper). Defra has since proposed basing the definition of radioactively contaminated land, in respect of human beings, in terms of the resulting 'harm', where 'harm' is, in turn, defined as 'lasting exposure' (Defra, 2005).

2 Lasting Exposure

As discussed above, Defra currently intends, in respect of human beings, to base the definition of radioactively contaminated land indirectly in terms of the resulting 'lasting exposure', the term introduced in Article 48 of the BSS. The definition of lasting exposure will be given in the statutory guidance, not in the regulations themselves. However, the term lasting exposure is not itself defined in the European Union's Basic Safety Standards Directive (BSS) (EC, 1996). In this context, the Agency

interprets the term lasting exposure as exposure that continues at a reasonably constant rate for a significant proportion of an individual's lifetime, ie some tens of years.

It is important to note that Article 53 relates to lasting exposures resulting from the 'after effects' of a radiological emergency or a past practice (and by implication from Article 48, a past work activity). In respect of radiological emergencies and consistent with the definition of lasting exposure adopted by the Agency, the term after effects is interpreted here as implying a timescale of at least a few years following an accident. Thus the advice given here does not apply in the short to medium term following an accident but may be relevant in the longer term.

3 Dose Criteria for Intervention

3.1 Existing international and national advice

The International Commission on Radiological Protection (ICRP) is the primary international body for recommending radiological protection standards. Its latest recommendations for an overall system of protection were issued in 1990 as ICRP Publication 60 (ICRP, 1991). The overall aims of the ICRP system of radiological protection are to avoid deterministic effects and to reduce stochastic effects to acceptable levels.

The recommendations in ICRP Publication 60 have been embodied in international legislation including the European Union's Basic Safety Standards Directive (BSS) (EC, 1996). The biological basis of radiological protection, the ICRP system of radiological protection and the associated principles for protection are summarised in Appendix C.

Since the aim of the proposed regulations is to provide a system for the identification and remediation of land where contamination is currently causing lasting exposures to radiation, the principles for intervention apply. Indeed, Articles 48 and 53 appear in Title IX of the BSS, which relates to intervention. Interventions are situations where the sources, pathways and exposed individuals are already in place when a decision on control has to be taken. Within the BSS, intervention is defined as a human activity that prevents or decreases the exposure of individuals from sources which are not part of a practice or which are out of control, by acting on sources, transmission pathways and individuals themselves.

The ICRP principles for intervention are *justification* (the intervention action should do more good than harm) and *optimisation* (the net benefit should be maximised). It follows that the use of dose limits, or constraints, specified for practices as the basis for deciding on a level at which intervention is invoked, might involve measures that would be out of proportion to the benefit obtained and, therefore, would conflict with the principle of justification. Thus, the ICRP recommends that dose limits for practices (and, by inference, dose constraints) do not apply in intervention situations. This is also clearly stated in the final part of Article 48. There will, of course, be some level of dose approaching that which would cause serious deterministic effects, where some form of intervention will be almost always required.

The ICRP recommended that an annual dose* approaching 100 mSv will almost always justify intervention, whereas an annual dose approaching about 10 mSv may be used as a generic reference

* Unless otherwise stated, the term 'dose' refers to 'effective dose' as defined by the ICRP (1991).

level below which intervention is not likely to be justifiable for some prolonged exposure situations (ICRP, 1999). In 1998 the NRPB issued advice that intervention will almost certainly be justified on health grounds if the projected lifetime dose from the contamination to an individual member of the critical group is likely to exceed 1 Sv (this corresponds to a dose rate around 10 to 20 mSv y^{-1}) (NRPB, 1998). This is consistent with the dose criterion for considering the more resource intensive and disruptive countermeasures after an accident (NRPB, 1997). The International Atomic Energy Agency considers that cleanup is usually required for annual doses attributable to the contamination ranging from 1 to 10 mSv, and is almost always required for annual doses (from the contamination) in the range 10 to 100 mSv (IAEA, 1998). The ICRP also recommended action levels for intervention for radon that correspond to an annual dose from radon in the range 3 to 10 mSv (ICRP, 1993b). The UK Action Level for radon in homes of 200 Bq m^{-3} (NRPB, 1990) corresponds to a dose around 10 mSv y^{-1}.

3.2 Criteria in relation to the proposed regulations

On the basis of this existing advice, and relevant national circumstances, the Health Protection Agency considers that intervention actions would normally be justified if people were receiving a dose around 10 mSv y^{-1} from the contamination. This view is cautious in relation to ICRP guidance.

The Agency notes that the purpose of the regulations is to identify radioactively contaminated land. Under Part IIA and Article 53, once the land is identified it should be investigated and demarcated, and actions commensurate with the hazard should be undertaken. Intervention actions would be undertaken only if they were justified. In order to minimise unnecessary blight, Defra wishes that, following determination of land as radioactively contaminated land, it would be likely that subsequent action would be justified. Such action might include further assessments and subsequent inspections as well as actions to restore the land and to mitigate the effects of the exposure. All these are covered by the term 'remediation' as defined in Part IIA.

Hence, the Agency considers that the designation of land as radioactively contaminated land should be based on a level of exposure at which it is appropriate that the site is investigated and remedial options are considered, but that intervention actions need not necessarily be undertaken as they may not be justified.

The level of exposure at which detailed site investigation is appropriate and at which intervention should be *considered* is clearly below 10 mSv y^{-1}.

4 Advice on Criteria for the Designation of Radioactively Contaminated Land

The Agency therefore considers that a level of 'lasting exposure' in the region of a few millisievert per year is appropriate for the designation of land as radioactively contaminated land. However, given the need for more straightforward advice appropriate for regulatory implementation, a single value of 3 mSv y^{-1} (effective dose) has been selected from the range. It should be stressed that an element of judgement was involved in arriving at this recommendation. Unqualified adoption of ICRP

recommendations in this area (ICRP, 1999) could lead to the selection of a somewhat higher value possibly approaching 10 mSv y^{-1}.

The proposed regulations must also reflect the requirement to avoid deterministic effects; thus supplementary dose criteria are required for the skin and lens of the eye. The Agency recommends the limits for these tissues are those recommended for practices by the ICRP (1991).

The Agency recognises that radioactive contamination may be very patchy or consist of small, highly active particles, referred to as 'hot particles'. Therefore it is necessary to consider situations where there is a low probability of exposure occurring, termed 'potential exposures', in addition to situations where exposure is likely to occur.

Defra has asked for clearly stated criteria based on dose for situations where exposures are certain or almost certain to occur, and for guidance on the treatment of potential exposures. The Agency's advice and guidance are given below.

4.1 Exposures likely to occur

For situations where exposures are being received or are likely to be received, the Agency recommends that land should be defined as radioactively contaminated land if any of the following conditions is satisfied:

a the annual dose from the contamination is greater than 3 mSv,

b the annual equivalent dose to the lens of the eye from the contamination is greater than 15 mSv,

c the annual equivalent dose to the skin from the contamination is greater than 50 mSv.

4.2 Potential exposures

The ICRP has given some guidance on the treatment of potential exposures in the context of practices but little in relation to intervention situations. In relation to potential exposures within practices, the ICRP has proposed that 'If the doses, should they occur, will not be in excess of dose limits, it is adequate to use the product of the expected dose and its probability of occurrence as if this were a dose that is certain to occur' (ICRP, 1991).

The limits on doses from practices recommended by the ICRP are intended to limit the occurrence of stochastic effects to 'acceptable' levels. These limits are set within the linear range of the dose–response relationship for stochastic health effects. Application of these limits on dose is also considered 'sufficient to ensure the avoidance of deterministic effects in almost all body tissues and organs' (ICRP, 1991). Separate equivalent dose limits are also recommended by the ICRP for some tissues to prevent deterministic effects. Following this, the ICRP guidance on the treatment of potential exposures within practices can be interpreted as implying that if the doses that could occur are below those at which deterministic effects could occur and are within the linear range of the dose–response relationship for stochastic effects, then it is appropriate to use the product of the expected dose and its probability of occurrence as if this were a dose that is certain to occur.

Although the ICRP guidance discussed above relates specifically to potential doses within practices, it is considered that the same general approach would be equally valid with respect to the treatment of potential doses within intervention situations, such as those relating to the remediation of contaminated land.

In this context it is important to note that the ICRP has concluded that 'at levels of effective dose below about 0.1 Sv, only stochastic effects are expected to occur and the probability of their occurrence is assumed to be directly proportional to the effective dose' (ICRP, 1993a). This is generally correct, but for highly non-uniform exposures, such as, for example, may arise from a 'hot particle' on the skin or eye, or following ingestion of such a particle, some deterministic effects may still arise at a level of dose of 100 mSv. Serious deterministic effects in two relevant organs, the skin and the lens of the eye, are very unlikely to occur at exposures below the corresponding ICRP dose limits for members of the public, ie at an equivalent dose to the skin of 50 mSv y^{-1} and to the lens of the eye of 15 mSv y^{-1}.

The Agency therefore recommends that, if the dose that would be received from hot particles or other heterogeneous contamination is less than or equal to 50 mSv y^{-1}, and the equivalent doses to the lens of the eye and skin are below 15 and 50 mSv y^{-1}, respectively, then it is appropriate to compare the product of the annual dose that could be received (effective dose) and the annual probability of the dose being received (probability) with the dose criterion of 3 mSv y^{-1}. These dose levels are selected to essentially avoid the possibility of any deterministic effects.

If hot particles or heterogeneous contamination could result in doses above 50 mSv y^{-1}, or equivalent doses to the lens of the eye or to skin above 15 and 50 mSv y^{-1}, respectively, then consideration needs to be given to the possibility of deterministic health effects in addition to the probability of the dose being received. At annual doses above around 100 mSv consideration also needs to be given to the potential non-linearity of the dose–response relationship.

The Agency's advice for potential exposures is summarised in the table overleaf.

5 Discussion

The Agency has recommended dose criteria to be used in the designation of radioactively contaminated land in the context of lasting exposure. The Agency has defined lasting exposure to mean exposure that continues at a reasonably constant level for a significant proportion of an individual's lifetime. The dose criteria recommended by the Agency apply to the incremental dose from the contamination (ie the total dose minus the natural background dose). Dose criteria have been recommended for situations that are certain to occur and for situations where the contamination is very heterogeneous and thus the probability of exposure is much less than unity.

The existing Part IIA contaminated land regulations make use of the concept of 'significant possibility of significant harm' in establishing the need for remediation. Radiological protection does not use the term 'significant possibility of significant harm', so there is no direct correspondence. Instead, radiological protection deals with acceptable or unacceptable levels of risk. Hence protection of human health in the proposed regulatory regime for radioactively contaminated land is considered in the context of lasting exposure. It may be possible, however, to interpret a dose corresponding to an unacceptable level of risk as a dose causing 'a significant possibility of significant harm' from long-term exposure. The ICRP

Criteria for the designation of land as radioactively contaminated land in the case of potential exposures

Annual dose level		Status of land
Effective dose ≤ 50 mSv and Equivalent dose to lens of eye ≤ 15 mSv and Equivalent dose to the skin ≤ 50 mSv	Effective dose x Probability ≤ 3 mSv y^{-1}	Not radioactively contaminated land
	Effective dose x Probability > 3 mSv y^{-1}	**Radioactively contaminated land**
Effective dose > 50 mSv and/or Equivalent dose to lens of eye > 15 mSv and/or Equivalent dose to the skin > 50 mSv	Decisions on whether the land should be classified as **radioactively contaminated land** or not will need to be taken on a case by case basis and should be based on consideration of the following factors: **a** the possibility of occurrence and severity of deterministic health effects, **b** the potential non-linearity of the dose–response relationship for stochastic effects (for doses above 100 mSv), **c** the probability of doses being received, **d** practical issues related to detectability and remediation.	

(1999) states that the risk of stochastic effects at a dose level of 100 mSv y^{-1} would be too high to be considered acceptable. Hence a dose level of 100 mSv y^{-1} could be taken to be the level corresponding to 'a significant possibility of significant harm' as defined in Part IIA. As is clear from this discussion, the levels recommended here for the definition of land as radioactively contaminated land do not correspond to a level of 'significant harm' and should not be interpreted as such.

It should be remembered that the dose criterion of 3 mSv y^{-1} from the contamination refers to the mean dose to a member of the critical group. Since the habits of the critical group are chosen such that they receive the highest doses, the dose to an average individual will be less. Experience has shown that the dose to a typical individual is significantly lower than that to a member of the critical group.

A dose of 3 mSv y^{-1} broadly corresponds to the average individual radiation exposure (including doses from medical exposures) in the UK. Thus, an additional dose of 3 mSv y^{-1} would correspond to an approximate doubling of the average annual dose. This should be viewed in the context of the fact that significant areas of the UK experience natural background exposures of two or three times the average. The lifetime fatal cancer risk at an exposure rate of 3 mSv y^{-1} is estimated by the ICRP to be about one in one-hundred (ICRP, 1991).

In circumstances where assessed doses are greater than the dose criteria, the land should be designated as radioactively contaminated land and intervention to reduce doses should be considered but not

necessarily undertaken if it is not justified. Where assessed doses are less than the dose criteria, the land would not be categorised as radioactively contaminated land but this would not preclude the use of simple measures to reduce doses where appropriate.

6 References

EC (1996). Council Directive 96/29/Euratom of 13 May 1996 laying down the basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation. *Off J Eur Commun,* L159.

GB Parliament (1990). Environmental Protection Act 1990. London, HMSO.

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ICRP (1991). 1990 recommendations of the International Commission on Radiological Protection. ICRP Publication 60. *Ann ICRP*, **21**(1–3).

ICRP (1993a). Protection from potential exposure: a conceptual framework. ICRP Publication 64. *Ann ICRP*, **23**(1).

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ICRP (1999). Protection of the public in situations of prolonged radiation exposure. ICRP Publication 82. *Ann ICRP*, **29**(1–2).

NRPB (1990). Human exposure to radon in homes. *Doc NRPB,* **1**(1), 17–32.

NRPB (1997). Intervention for recovery after accidents. *Doc NRPB*, **8**(1), 1–20.

NRPB (1998). Radiological protection objectives for land contaminated with radionuclides. *Doc NRPB*, **9**(2), 1–12.

Appendix A

Letter from the Department for Environment, Food and Rural Affairs

Dr John Cooper
National Radiological Protection Board
Chilton
Didcot
Oxon
OX11 0RQ

18 February 2005

Dear John

Radioactively Contaminated Land – Request for NRPB Advice

As you are aware we are working to introduce a regime for radioactively contaminated land, to mirror that for chemically contaminated land found in Part IIA of the Environmental Protection Act 1990. The objectives for the regime are broadly the same as those for Part IIA that is to say to ensure the protection of human health and the wider environment. A further over-riding objective is to ensure that the UK complies with its obligations to transpose Articles 48 and 53 of Euratom Directive 96/29. The regime will therefore provide a system for the identification and remediation of land where contamination is causing lasting exposures to radiation and where intervention is liable to be justified.

Under the Part IIA regime contaminated land arises where 'significant harm' is being caused or where there is a significant possibility of such harm being caused by substances in, on or under the land. Statutory guidance is provided on what constitutes significant harm and the significant possibility of significant harm. Our preferred approach is to retain this definition for dealing with the effects of radioactivity on the wider environment but, in respect of human beings, to base the definition upon the words in the Directive of 'lasting exposure resulting from the after-effects of a radiological emergency or past or old practice or work activity' or there being a 'significant possibility' of such exposure being caused. A possible text of the definition is enclosed.

The definition of lasting exposure and its significant possibility will be expanded upon in statutory guidance which would guide on what constituted 'lasting exposure' and would, in effect, define radioactively contaminated land. A local authority is obliged to act in accordance with statutory guidance when determining whether land appears to be contaminated. Subsequently, intervention would be undertaken but only if it was justified to do so, and its form scale and duration would be optimised. (Article 48(2) of 96/29 Euratom refers.)

In order to minimise unnecessary blight we wish that, following a determination of land as radioactively contaminated land, it would be likely that subsequent action would be justified. Such action might include further assessments of the condition of the contaminated land or adjoining land and subsequent inspections for keeping the condition of the land under review as well as actions to restore the land or mitigate the effects of the exposure. All of which are covered by the term 'remediation' as defined in 78A(7) of Part IIA.

Discussions with external stakeholders have indicated a preference for a clearly stated criterion based upon dose where exposures are certain or almost certain to occur and for guidance on the treatment of potential exposures including those low probability/high dose events that may give rise to deterministic effects. This latter guidance could be in the form of additional dose criteria or factors that should be taken into account in a site by site assessment. I am therefore writing to you, on behalf of both the UK government and the Devolved Administrations, to seek the NRPB's formal advice on these.

The advice must be clear, justifiable in the context of radioactively contaminated land and Articles 48 and 53 of the Directive 96/29/Euratom, represent best scientific advice taking into account both UK and international sources and permit the development of practical measurable operational quantities. We expect that as a result it will command public confidence. The reasoning behind your advice should be explained since the regime, including your advice, will be the subject of public consultation in July of this year.

Yours sincerely

Chris Wilson
RAS4

cc Chris de Grouchy RAS
Hilary Walker DoH
Radioactively Contaminated Land Steering Group } by email

enc.
Extract from Draft Radioactive Contaminated Land (Modification of Enactments) Regulations (England) 2006

Extract from Draft Radioactive Contaminated Land (Modification of Enactments) Regulations (England) 2006

'Contaminated land' is any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that—

(a) significant harm is being caused or there is a significant possibility of such harm being caused, other than harm to human health;
(b) significant pollution of controlled waters is being caused or there is a significant possibility of such pollution being caused; or
(c) lasting exposure resulting from the after-effects of a radiological emergency, past practice or work activity is being caused to humans or there is a significant possibility of such exposure being caused;

Appendix B

Articles 48 and 53 of the European Union's Basic Safety Standards Directive*

Article 48 Application

1 This Title shall apply to intervention in cases of radiological emergencies or in cases of lasting exposure resulting from the after-effects of a radiological emergency or a past or old practice or work activity.

2 The implementation and extent of any intervention shall be considered in compliance with the following principles:

- intervention shall be undertaken only if the reduction in detriment due to radiation is sufficient to justify the harm and costs, including social costs, of the intervention,
- the form, scale and duration of the intervention shall be optimized so that the benefit of the reduction in health detriment less the detriment associated with the intervention, will be maximised,
- dose limits, as laid down in Articles 9 and 13, shall not apply to intervention; however, the intervention levels established in application of Article 50 (2) constitute indications as to the situations in which intervention is appropriate; furthermore, in cases of long term exposure covered by Article 53, the dose limits set out in Article 9 should normally be appropriate for workers involved in interventions.

Article 53 Intervention in cases of lasting exposure

Where the Member States have identified a situation leading to lasting exposure resulting from the after effects of a radiological emergency or a past practice, they shall, if necessary and to the extent of the exposure risk involved, ensure that:

a the area concerned is demarcated;

b arrangements for the monitoring of exposure are made;

c any appropriate intervention is implemented, taking account of the real characteristics of the situation;

d access to or use of land or buildings situated in the demarcated area is regulated.

* EC (1996). Council Directive 96/29/Euratom of 13 May 1996 laying down the basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation. *Off J Eur Commun*, L159.

Appendix C

Summary of the System of Radiological Protection

C1 Biological basis

When ionising radiation (in this context, alpha and beta particles, and gamma rays) passes through body tissue, it transfers energy to the atoms that make up the tissue. Thus, a dose of radiation is reported in terms of the ratio of the deposited energy to the mass of the irradiated tissue (joules per kilogram). An absorbed dose of one joule per kilogram is termed a gray (Gy). Doses above a few gray to the entire body delivered over a short period of time, say up to a few days, will cause gross tissue decay leading to death within a few days or weeks. This type of health effect, which is inevitable following a dose of radiation above a certain level, is called a *deterministic* effect.

Radiation can cause health effects at lower doses. Cancer is predominantly the health effect of concern. The likelihood of incurring a radiation-induced cancer is in proportion to the radiation dose. The evidence for this is based on observations on populations receiving radiation doses of a few tens of milligray upwards. For the purposes of setting radiological protection standards, it is assumed that the likelihood of incurring a radiation-induced health effect is linearly proportional to the radiation dose for low doses and dose rates. This is referred to as the linear no-threshold (LNT) assumption. The risk of cancer from exposure to ionising radiation is not great. On average, an additional dose of 1 mGy to the whole body from gamma radiation corresponds to an additional risk of about one in twenty-thousand over a lifetime. This type of health effect is called a *stochastic* effect.

All types of radiation are not equally effective in causing cancer. Studies on animals and observations on exposed human populations have shown that absorbed doses delivered by alpha particles are more effective than are beta particles or gamma rays. For radiological protection purposes, a radiation dose from alpha particles is considered to be twenty times more likely to cause cancer than the same absorbed dose of beta or gamma radiation. Thus, an absorbed dose from alpha particles is multiplied by a radiation weighting factor of twenty. The resulting quantity is termed the equivalent dose. It has the unit sievert (Sv).

Radionuclides can be taken into the body by ingestion, inhalation, absorption through the skin or through cuts and abrasions. Once in the body, different radionuclides may localise in different tissues. The distribution of a radionuclide in the body will depend upon its chemical and physical properties as well as the route of intake. Thus, different radionuclides may preferentially irradiate different tissues. The risk of cancer following exposure to radiation varies between tissues. To take account of this, the equivalent dose to a particular organ or tissue is multiplied by a tissue weighting factor that reflects the risk associated with that tissue or organ. The resultant quantity summed over all irradiated tissues is called the effective dose*. It provides an equal basis for comparing exposures from different radionuclides.

* Unless specified otherwise, 'dose' is taken to mean 'effective dose' from here.

The LNT assumption has a number of important implications. Firstly, it is not possible to specify a level of dose below which there is no risk to health. Therefore, the process of setting radiological protection standards has to take account of the circumstances in which the exposures are incurred including the benefits arising from a particular source of exposure. Secondly, within the range of doses for which the LNT assumption is valid – whole body doses up to about 500 mSv or effective doses up to around 100 mSv (ICRP, 1993) – exposures from different sources of radiation can be considered independently of each other. For example, an additional dose of 1 mSv to an individual carries with it the same level of additional risk whether the individual is already receiving a dose of, say, 2 or 20 mSv.

C2 System of radiological protection

The International Commission on Radiological Protection (ICRP) is the primary international body for recommending radiological protection standards. Its latest recommendations for an overall system of protection were issued in 1990 as ICRP Publication 60 (ICRP, 1991). The overall aims of the ICRP system of radiological protection are to avoid deterministic effects and to reduce stochastic effects to acceptable levels.

The recommendations in ICRP Publication 60 have been embodied in international legislation including the European Union's Basic Safety Standards Directive (BSS) (EC, 1996). UK legislation on radiological protection must address the requirements of the BSS.

The ICRP system of radiological protection distinguishes between two categories of exposure: practices and interventions.

Practices are situations where the exposure of individuals is being increased. Emphasis is on the control of the source of exposure and this can generally be planned for before commencing the practice. Examples of practices are the generation of electricity by nuclear power and the production of radioisotopes for medical or research usage. The ICRP principles of protection for practices are given in Box 1.

Interventions are situations where the sources, pathways and exposed individuals are already in place when a decision on control has to be taken. In such situations, protection can only be achieved by intervention, ie by removing or modifying existing sources or pathways, or reducing the numbers of people exposed. The system of radiological protection recommended by the ICRP for intervention has the principles given in Box 2.

In most cases, intervention cannot be applied to the source of the exposure and has to be applied in the environment and, particularly in the case of accidents, to an individual's freedom of action. Thus a programme of intervention will always have some disadvantages but should always be justified in the sense that it does more good than harm. It follows that the use of dose limits, or constraints, specified for practices as the basis for deciding on a level at which intervention is invoked might involve measures that would be out of proportion to the benefit obtained and, therefore, would conflict with the principle of justification. Thus, the ICRP recommends that dose limits for practices (and, by inference, dose constraints) do not apply in intervention situations. There will, of course, be some level of dose approaching that which would cause serious deterministic effects, where some form of intervention will be almost always required. Intervention situations are also distinct from practices in that the principles of justification and optimisation apply to the measures taken to reduce doses, termed a remedial action, rather than to the exposures.

Box 1 ICRP principles for practices

Justification of a practice
No practice involving exposures to radiation should be adopted unless it produces sufficient benefit to the exposed individuals or to society to offset the radiation detriment it causes.

Optimisation of protection
In relation to any particular source within a practice, the magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposures where these are not certain to be received should all be kept as low as reasonably achievable, economic and social factors being taken into account. This procedure should be constrained by restrictions on the doses to individuals (dose constraints), or the risks to individuals in the case of potential exposures (risk constraints), so as to limit the inequity likely to result from the inherent economic and social judgements.

Individual dose and risk limits
The exposure of individuals resulting from the combination of all the relevant practices should be subject to dose limits, or to some control of risk in the case of potential exposures. These are aimed at ensuring that no individual is exposed to radiation risks that are judged to be unacceptable from these practices in any normal circumstances. Not all sources are susceptible to control by action at the source and it is necessary to specify the sources to be included as relevant before selecting a dose limit.

In simpler terms, these principles may be phrased as follows. Radiation can cause harm and therefore any intended use should be worthwhile (justification) and, this being the case, all reasonable steps should be taken to reduce exposures (optimisation). Doses and risks from uses of radiation should be kept within pre-defined limits or constraints (dose and risk limitation). Obviously, this principle does not apply to sources which cannot be controlled.

Box 2 ICRP principles for intervention

Justification of intervention
The proposed intervention should do more good than harm, ie the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including social costs, of the intervention.

Optimisation of intervention
The form, scale and duration of the intervention should be optimised so that the benefit of the reduction of dose, ie the benefit of the reduction in radiation detriment, less the detriment associated with the intervention, should be maximised.

C3 Application of radiological protection principles to contaminated land

Contaminated land situations may be considered either a practice or intervention depending on the precise circumstances (ICRP, 1999). Where contaminated land is to be subject to a change of use leading to greater public access then this would introduce additional or new exposures to the radionuclides and would be considered a practice. Where, however, the 'current use' of the land is being addressed, the principles of intervention apply.

C4 References

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Documents of the Health Protection Agency
Radiation, Chemical and Environmental Hazards
RCE-2
March 2006
ISBN 0 85951 575 3
£11.50

This report is printed on chlorine-free paper