



Using RCLEA - the Radioactively Contaminated Land Exposure Assessment Methodology

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The Radioactively Contaminated Land Exposure Assessment Methodology - RCLEA

Summary

RCLEA is Defra's recommended approach for the exposure assessment of a site under the extended Part 2A regime for managing contaminated land. It complements the Contaminated Land Exposure Assessment (CLEA) approach for non-radioactive contamination. RCLEA is designed to support decision making under the extended regime; it may have wider applications but care is needed if the methodology is applied in other circumstances.

The methodology is based on a set of mathematical models and data that calculate radiation doses from radionuclides in soil. These have been implemented as a software application in Microsoft Excel®, published by Defra as CLR 15, which is accompanied by a detailed technical report (CLR 14), and a more general summary and user guide (CLR 13).

Using measured concentrations of radionuclides, RCLEA calculates potential doses for comparison with regulatory criteria. It can also be used to calculate 'Guideline Values' in terms of radionuclide concentrations if reliable measurements are not yet available. In addition to specifying radionuclides present (and concentrations, if known), the user has four basic options to select from:

- ▲ reference land uses (consistent with CLEA), including residential (with or without home-grown vegetables), allotments and commercial/industrial use;
- ▲ building type (timber framed or brick);
- ▲ age (adult, infant or child); and
- ▲ sex (male or female).

If no preference is specified, the worst-case assumptions will be adopted. The user can specify a greater level of detail if required by undertaking a 'site-specific' calculation. This allows the user to define a new land use and adjust specific parameter values, such as the time spent on the contaminated site, so they better represent the situation.

The dose calculated with RCLEA can be compared with the criteria which apply for radioactivity under the extended Part 2A regime (provided the scenarios and assumptions are appropriate), and appropriate decisions made. Where results remain inconclusive, further assessment is likely to be needed, perhaps involving more detailed modelling.

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List of Abbreviations

CLEA	Contaminated Land Exposure Assessment
Defra	Department for Environment, Food and Rural Affairs
NRPB	National Radiological Protection Board (now the Radiation Protection Division of the Health Protection Agency)
RCLEA	Radioactively Contaminated Land Exposure Assessment
RSGV	Radioactivity in Soil Guideline Value (for a single radionuclide present in isolation in contaminated land)
SGV	Soil Guideline Value (for non-radioactive contaminants)

1 Introduction

- 1.1 The Part 2A regime¹ for managing contaminated land has been extended to include radioactive contamination. The new arrangements, including amended Statutory Guidance, are set out in Defra Circular 01/2006 “Contaminated Land”². Since this was issued there has been a change in the legal definition of “substance” that removes the existing exclusion of radon and its decay products from the regime.
- 1.2 The Radioactively Contaminated Land Exposure Assessment methodology (RCLEA) is Defra’s recommended approach for the exposure assessment of a site under the extended regime, with respect to radioactivity in soil and human health. It is based on the original Contaminated Land Exposure Assessment (CLEA) approach that was developed for the assessment of non-radioactive contamination, although there are several important differences due to the nature of radioactive contaminants. The version of CLEA on which RCLEA is based is has now been superseded, but RCLEA remains compatible with the revised approach.
- 1.3 This document, CLR 13, gives an overview of RCLEA and presents guidance on how it may be used to carry out exposure assessments in connection with the Part 2A regime. Section 2 gives a summary of RCLEA, and Section 3 deals with its use in individual cases.
- 1.4 CLR 13 is primarily intended for local authority and Environment Agency staff responsible for implementing the Part 2A regime. It should be read in conjunction with the Part 2A Statutory Guidance and procedures and in particular those sections relating to radioactively contaminated land and its identification. Key parts of the Statutory Guidance of relevance to the use of RCLEA are reproduced in Appendix A to this document, whilst Appendix B presents basic guideline values for radioactivity in soil.
- 1.5 CLR 13 should also be read in conjunction with the RCLEA Technical Report³ and the RCLEA software application – CLRs 14 and 15 ⁴. A user guide for the

¹ Part 2A of the Environmental Protection Act 1990, as amended - “Contaminated Land”

² Annex 3 contains the Part 2A Statutory Guidance.

³ Penfold JSS, Robinson PC, Walke RC and Watson CE (2011). RCLEA: The Radioactively Contaminated Land Exposure Assessment Methodology - Technical Report. CLR14, Version 1.2, March 2011.

RCLEA software application is included in 0, and a worked example of its use is provided in Appendix D.

- 1.6 The report is an update of the original, issued in October 2006. The revision has been made to take account of a change in the legal definition of “substance” that removes the exclusion for radon and its decay products. The updated methodology therefore includes a method for assessing the significance of radon.

2 Background

The Basis for Determining whether Land is Contaminated Land by Virtue of Radioactivity

- 2.1 Under Part 2A, land is determined as contaminated land by virtue of radioactivity if ‘harm’ is being caused or if there is a significant possibility of ‘harm’ being caused. The Statutory Guidance says that (subject to the guidance in the rest of the chapter) the local authority should regard ‘harm’ as being caused where lasting exposure gives rise to doses that exceed one or more of the following criteria:

- ▲ An effective dose of 3 millisieverts per annum;
- ▲ An equivalent dose to the lens of the eye of 15 millisieverts per annum; or
- ▲ An equivalent dose to the skin of 50 millisieverts per annum.

- 2.2 Henceforward, these criteria are referred to as the ‘Statutory Guidance criteria’. In practice, it is very unlikely that the criterion for the lens of the eye would be exceeded without the other criteria also being exceeded.

Scope of RCLEA

- 2.3 RCLEA is Defra’s recommended methodology for the exposure assessment of land with respect to radioactivity and the Statutory Guidance criteria. When applied for Part 2A purposes it must be used in compliance with Statutory Guidance on the definition and identification of contaminated land (for example a ‘pollutant linkage’ must be established). The results calculated with RCLEA can

⁴ The RCLEA publications CLRs 13, 14 and 15 are being made available for downloading from the contaminated land pages on the Environment Agency website: <http://www.environment-agency.gov.uk/research/planning/33746.aspx>

be compared with the Statutory Guidance criteria to help in deciding whether harm is being caused. The outcome can support a decision about whether the site should be determined as contaminated land under Part 2A, eliminated from consideration, or whether more work is needed to establish its condition. RCLEA can also be used to calculate radionuclide concentrations in soil corresponding to the Statutory Guidance criteria. These can then be compared with measured concentrations to establish the condition of the land.

- 2.4 RCLEA may be used to carry out initial screening as part of a desktop study to establish whether a site warrants further investigation with respect to radioactivity. It is thus envisaged that RCLEA will be employed to *screen out* (eliminate) sites with respect to the Statutory Guidance criteria and human health effects.
- 2.5 RCLEA may also be used in *determining* land as radioactively contaminated under Part 2A, in accordance with the Statutory Guidance. However, care should be taken to ensure that the scenarios and assumptions used are suitable. For instance, RCLEA has been designed for situations where the contamination is evenly dispersed over a relatively large area; it is not suitable for situations where the contamination is in the form of individual sources that can give rise to localised exposures (e.g. discrete items that have been luminised with radium). In addition RCLEA does not include consideration of potential exposures resulting from the migration of radionuclides in surface water or groundwater.
- 2.6 Although RCLEA can be used in applying the Statutory Guidance criteria in relation to 'harm' (by calculating potential radiation dose) it cannot be used on its own to establish 'significant possibility of harm'⁵. This requires an estimate or a calculation of probability that a person is exposed, in addition to considering potential 'harm'.
- 2.7 RCLEA, properly applied, should therefore help assessors to satisfy, for most circumstances, the Part 2A Statutory Guidance requirements at paragraph B51A(a):

'a scientific and technical assessment of the dose arising from the pollutant linkage, according to relevant, appropriate, authoritative and scientifically based guidance on such assessments' (see Appendix 1 for full text);

and paragraph B51F:

⁵ See Appendix A for further information on the terms 'harm', 'significant possibility...' etc.

'the estimation of an effective dose and an equivalent dose should be undertaken in accordance with Articles 15 and 16 of Council Directive 96/29/EURATOM of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation' (see Appendix 1 for full text).

Use of RCLEA

- 2.8 RCLEA is intended primarily for use by local authorities and the Environment Agency dealing with issues of radioactively contaminated land, including carrying out Part 2A detailed inspections and formal determinations. For most simple applications, use of the methodology does not require specialised knowledge of radiation protection, although familiarity with a number of basic definitions and terms is necessary. For some more detailed applications of RCLEA – involving modification to input data for site-specific assessments – specialised knowledge of radiation protection and radiological impact assessment modelling may be required.
- 2.9 The methodology may have wider uses, for instance to conduct radiological impact assessment calculations for planning purposes. However, before using RCLEA for any purpose other than Part 2A decision-making, it is recommended that the appropriateness of RCLEA is considered carefully. Reference should be made to the RCLEA Technical Report, which contains details of the assumptions, models and data used within RCLEA.

RCLEA Assumptions, Models and Data

- 2.10 The basis, scope and key assumptions of RCLEA were determined by reviewing existing assessment methodologies for radioactively and non-radioactively contaminated land, including CLEA⁶. Although RCLEA adopts the same principles as CLEA, there are some fundamental differences in its application. Notably, unlike CLEA, RCLEA can provide a direct estimate of harm in terms of estimated radiation dose. Furthermore, for radioactivity the additional pathway of external radiation must be considered, in addition to ingestion, inhalation and direct contact.

⁶ Defra and Environment Agency (2002). The Contaminated Land Exposure Assessment Model (CLEA): Technical basis and algorithms. R & D Publication CLR 10, March 2002. Note that this has been superseded in 2009 but formed the basis of RCLEA.

- 2.11 RCLEA considers a simplified representation of contaminated soil. The area of contaminated land is assumed to be larger than that occupied by the person whose exposure is assessed. 'Patchy' contamination can be represented by applying a simple scaling factor to the dose estimates. The contamination is assumed to be uniformly distributed through soil to a depth of 1 metre from the surface. It is recommended that RCLEA is not applied to buried contamination without separate measurement or calculation of radiation dose rates above the buried contamination.
- 2.12 Like CLEA, RCLEA describes potential exposure scenarios in terms of the 'land use' of the contaminated site. Three reference land uses are considered in RCLEA, and are the same as those considered in CLEA. These are intended for use in 'generic' assessments of potentially contaminated sites.
- ▲ The **residential** land use scenario considers a two-storey property with a private garden, occupying 0.2 hectares. Infants and adults are assumed to spend most of their time at home, whilst children spend time away from the home at school. Part of the garden can be assumed to be used as a vegetable patch, and potentially contaminated vegetables may be eaten.
 - ▲ The **allotment** land use scenario assumes a plot of 0.8 hectares in size. Adults are assumed to visit the allotment site four days a week for four hours per visit, sometimes accompanied by infants and/or children. The vegetables are assumed to be consumed by the allotment gardener and his/her household.
 - ▲ The **commercial/industrial** land use scenario is intended to reflect shops, offices, or a small light industrial park. The whole site is assumed to be 2 hectares in size, with buildings occupying 5% of the area. It is assumed that workers spend about 38 hours a week on the site, the majority of their time being indoors.
- 2.13 In addition to the land use, the user can select from options describing the building type, and the age and sex of the exposed person. For more detailed site-specific calculations, the user can adjust parameter values, such as the duration of exposure or atmospheric dust concentration. In this way, new site-specific land uses can be defined.
- 2.14 The equations used to calculate the potential intake of radionuclides in contaminated soil are essentially very similar to those considered in CLEA. Generally, the annual intake is determined from an intake rate combined with the exposure duration. For contaminated foodstuffs, an element-dependent factor is used to determine the concentration in vegetables based on the concentration

in soil. The annual radiation dose from ingestion and inhalation is then calculated using internationally recommended 'dose coefficients', which are age- and pathway-dependent.

- 2.15 The radiation dose from the external irradiation of a person is calculated using the radionuclide concentration in the soil, the exposure duration and internationally recognised dose coefficients for external irradiation. An allowance is made for the 'shielding' of a person from radiation by uncontaminated material when people are in houses.
- 2.16 If radium-226 is present RCLEA also calculates the potential radiation dose from inhalation of its radioactive daughter, radon-222, which is gaseous. Exposure is only assessed indoors (where the gas can accumulate rather than be dispersed). The concentration of gas can be determined based on an empirical relationship, or take account of particular site-specific factors like the characteristics of the building.
- 2.17 Default data have been defined for the three reference land uses, based on values used in CLEA. However, it should be noted that RCLEA does not adopt a 'distributional' approach like CLEA (in which some parameters are represented by probability distribution functions rather than single values). RCLEA adopts suitably cautious single values drawn from the distributions considered in CLEA. Most parameter values can be modified for a 'site-specific' calculation.
- 2.18 RCLEA includes data for 47 different radionuclides, which can be assessed separately or in combination. The radionuclides have been selected to include those most likely to be encountered in practice. Reference radionuclide-dependent data have been obtained from well-established databases.
- 2.19 The RCLEA models and data have been implemented in a software application. Its use is described in Section 3, 0 and Appendix D.

Radioactivity in Soil Guideline Values - RSGVs

- 2.20 RCLEA has been used to calculate *Radioactivity in Soil Guideline Values (RSGVs)* for individual radionuclides. These represent the minimum soil concentration that will reach the Statutory Guidance criteria for a given reference land use, if only a single radionuclide is present. RSGVs are generic values, and cannot take account of actual site conditions that can vary widely.
- 2.21 Paragraphs B51C, B51D and B51D (see Appendix A) of the Statutory Guidance set out in detail the conditions and requirements for the use of any guideline

values, including RSGVs, under Part 2A. These generic guideline values may be used to provide an indication of where land could, following investigation, be *eliminated* from further consideration under Part 2A with respect to radiological exposure. If radionuclide concentrations are known with some certainty, and the RCLEA scenarios and assumptions are applicable, then the site can be eliminated from further consideration if:

- ▲ Contamination is due to a single radionuclide, the concentration of which is markedly below the RSGV; or
- ▲ Contamination is with multiple radionuclides and the sum of their individual ratios to their respective RSGV is markedly less than 1.

2.22 In this context “markedly below” or “markedly less than” means that, in the particular circumstances of the site, a more detailed assessment would be unlikely to come to a different conclusion.

3 Using RCLEA

3.1 The Statutory Guidance (paragraph B20) says that detailed inspection⁷ under Part 2A may include any or all of the following broad types of investigation activity:

- ▲ Documentary review (desk-top study);
- ▲ Visual inspection (walk-over survey); and/or
- ▲ Intrusive investigation.

The boundaries between these types of inspection are not hard-and-fast, and in practice they are expected to contribute to an overall process suitable for the site⁸.

3.2 RCLEA can be used in association with all three types or stages of inspection. The methodology can be applied at the outset of the process making use of all available data and assumptions. The assumptions can be modified, and/or the data changed, as new information becomes available. If the concentration of radionuclides in soil is known, the annual dose to an exposed person can be estimated using RCLEA for comparison with the Statutory Guidance criteria.

⁷ Environment Agency guidance is available at:
<http://www.environment-agency.gov.uk/research/planning/33706.aspx>

⁸ See CLR 11 (“Model Procedures for the Management of Land Contamination”) for further guidance.

RCLEA can also calculate 'guideline values' of radionuclide concentrations in soil, as referred to in B51E of the Statutory Guidance.

- 3.3 If, during any part of the investigation process, the dose calculated with RCLEA is markedly below the Statutory Guidance criteria then the site can be *eliminated* (screened out) from the extended Part 2A regime - provided that the RCLEA scenarios and assumptions are appropriate for the particular site.
- 3.4 If the calculated dose is close to or above one or more of the Statutory Guidance criteria, then there are three possible courses of action.
- (a) Further investigation and data refinement can be undertaken, followed by additional calculation(s) using RCLEA, which might draw on the results of site investigation.
 - (b) The site can be determined as radioactive contaminated land (subject to all the requirements of the statutory guidance being fully met).
 - (c) Should the results of a RCLEA calculation with suitably refined assumptions remain close to the Statutory Guidance criteria, further advice should be sought from a suitable expert (perhaps involving additional calculations with different models) before a decision is made.
- 3.5 RCLEA will not be universally applicable. Although many parameter values can be modified to reflect 'site specific' conditions, in some cases the underlying models will not be able to adequately represent the particular circumstances, and alternatives may need to be considered. In such cases an assessment method tailored to the specific site will need to be developed. Users are therefore advised that, particularly where the calculated doses are close to the Statutory Guidance criteria, they should look critically at the suitability of RCLEA and its assumptions before either making a determination or deciding that no further consideration need be given to the site. In particular, paragraph B51D of the Statutory Guidance is relevant.

Initial Calculations with RCLEA

- 3.6 Initially, a generic assessment can be undertaken with the RCLEA application using limited site-specific data. Generic calculations can be made even when there is no reliable information about the site other than the radionuclide(s) suspected to be present. The user need only specify the radionuclide(s) of interest and other optional information, including:

▲ Land use;

-
- ▲ Building type;
 - ▲ Receptor age group and sex; and
 - ▲ The fraction of the land that is contaminated.
- 3.7 In selecting from these options, it is important to consider not only the current status of the land but any changes to the land or those exposed that do not require change of use planning permission. For example, there may be no children or infants living in a house, but tenants or owners can change and children and/or infants could subsequently be exposed. If the optional information is not specified the RCLEA application will automatically use worst-case assumptions.
- 3.8 If radionuclide concentrations are known with confidence, they can be entered and the RCLEA application will calculate the potential dose. If the concentrations are not known the application can calculate 'guideline values' that correspond to the concentration(s) that would result in the Statutory Guidance criteria being exceeded.
- 3.9 Generic calculations can be carried out at any stage of the process using the RCLEA application. Each calculation can be saved to a unique file.

Refining Calculations with RCLEA

- 3.10 Generic RCLEA calculations use a set of default assumptions, designed to be conservative. However, it may be the case that the results indicate that more realistic site-specific information should be considered. This would be the case if a generic calculation indicated that the Statutory Guidance criteria had been exceeded. In these circumstances, users can modify the parameters by selecting the *site-specific* calculation option. All such changes should be carefully considered and fully justified.
- 3.11 A site-specific assessment may require the definition of a new land use scenario. This can be defined by specifying: the age groups; the exposure pathways; the basic characteristics of the site (e.g. the concentration of respirable dust in air); the occupancy of the contaminated site by exposed individuals; the inadvertent soil ingestion rate; and the amount of soil contamination present on the skin.
- 3.12 Other parameters can also be modified as required, but caution should be exercised as the default parameter values have been selected on the basis of considerable research. Some parameters in RCLEA cannot be changed, such as

dose coefficients, which have been established by reference to international guidance.

- 3.13 As the RCLEA calculations are refined, it is usual for the calculated doses to *reduce*. This is because the reference assumptions usually overestimate rather than underestimate potential exposure.
- 3.14 A 'user guide' for the RCLEA software application is presented in 0 and a hypothetical 'worked example' is included in Appendix D.

Appendix A : Selected Paragraphs from the Part 2A Statutory Guidance on Contaminated Land 2006

A.1 The following parts of the Part 2A Statutory Guidance are reproduced for convenience.

Determining that “Harm so far as Attributable to Radioactivity is being Caused”

B.51A In relation to harm so far as attributable to radioactivity, the Local Authority should determine that land is contaminated land on the basis that such harm is being caused where:

(a) it has carried out a scientific and technical assessment of the dose arising from the pollutant linkage, according to relevant, appropriate, authoritative and scientifically based guidance on such assessments, having regard to any advice provided by the Environment Agency, and taking into account the requirements of paragraph B.51F;

(b) that assessment shows that such harm is being caused; and

(c) there are no suitable and sufficient risk management arrangements in place to prevent such harm.

B.51B In following any such guidance on the assessment of dose, the Local Authority should be satisfied that it is relevant to the circumstances of the pollutant linkage and land in question, and that any appropriate allowances have been made for particular circumstances.

B.51C To simplify such an assessment of dose, the Local Authority may use authoritative and scientifically based guideline values for concentrations of the potential pollutants in, on or under the land in pollutant linkages of the type concerned. If it does so, the Local Authority should be satisfied that:

(a) an adequate scientific and technical assessment of the information on the potential pollutant, using the appropriate, authoritative and scientifically based guideline values, shows that harm so far as attributable to radioactivity is being caused; and

(b) there are no suitable and sufficient risk management arrangements in place to prevent such harm.

B.51D In using any guideline values, the Local Authority should be satisfied that:

(a) the guideline values are relevant to the judgement of whether the effects of the pollutant linkage in question constitute harm attributable to radioactivity;

(b) the assumptions underlying the derivation of any numerical values in the guideline values (for example, assumptions regarding soil conditions, the behaviour of potential pollutants, the existence of pathways, the land-use patterns, and the presence of human beings) are relevant to the circumstances of the pollutant linkage in question;

(c) any other conditions relevant to the use of the guideline values have been observed (for example, the number of samples taken or the methods of preparation and analysis of those samples or of radiation surveys);

(d) appropriate adjustments have been made to allow for the differences between the circumstances of the land in question and any assumptions or other factors relating to the guideline values; and

(e) the basis of derivation of the guideline values has taken into account the requirements of paragraph B.51F.

B.51 E The Local Authority should be prepared to reconsider any determination based on such use of guideline values if it is demonstrated to the authority's satisfaction that under some other more appropriate method of assessing the risks the Local Authority would not have determined that the land appeared to be contaminated land.

B.51F The estimation of an effective dose and an equivalent dose should be undertaken in accordance with Articles 15 and 16 of Council Directive 96/29/EURATOM of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation. The estimation of an effective or equivalent annual dose should not include the local background level of radiation from the natural environment.

Determining that "There is a Significant Possibility of Harm so far as Attributable to Radioactivity being Caused"

B.51G The Local Authority should determine that land is contaminated land on the basis that there is a significant possibility of harm so far as attributable to radioactivity being caused (as defined in Chapter A), where:

(a) it has carried out a scientific and technical assessment of the potential dose arising from the pollutant linkage, according to relevant, appropriate, authoritative and scientifically based guidance on such assessments, having regard to any advice provided by the Environment Agency, and taking into account the requirements of paragraph B.51F;

(b) that assessment shows that there is a significant possibility of such harm being caused; and

(c) there are no suitable and sufficient risk management arrangements in place to prevent such harm.

B.51H In following any such guidance on assessment of the potential dose, the Local Authority should be satisfied that it is relevant to the circumstances of the pollutant linkage and land in question, and that any appropriate allowances have been made for particular circumstances.

Appendix B : Radioactivity in Soil Guideline Values

- B.1 A special type of Guideline Value for contamination with a single radionuclide is the minimum soil concentration that can be calculated with RCLEA for a given reference land use (with default parameter value assumptions) such that one of the Statutory Guidance criteria are exceeded.
- B.2 This is referred to as the **Radioactivity in Soil Guideline Value (RSGV)**; RSGVs are shown in Table B.
- B.3 In this table, radionuclides denoted with a * include contributions from short-lived daughter radionuclides and Ra-226[^] includes an assessment of the potential exposure to the gaseous daughter of Ra-226, Rn-222. Natural uranium is taken to contain 99.2745% U-238, 0.72% U-235 and 0.0055% U-234 by mass; therefore 1 Bq of natural uranium is assumed to contain 0.483 Bq U-238, 0.022 Bq U-235 and 0.495 Bq U-234. Natural thorium is assumed to be refined thorium of sufficient age that the Th-232 decay chain has re-established equilibrium (20 years or so). Therefore, 1 Bq of natural thorium is assumed to contain 0.333 Bq of Th-232, 0.333 Bq of Th-230 and 0.333 Bq of Th-228 as well as 0.333 Bq of Ra-228 that has ingrown.

Table B: Radioactivity in Soil Guideline Values, in Bq kg-1 – Only for Use Where a Single Radionuclide is Present

Radio-nuclide	Residential (with home grown produce)	Residential (without home grown produce)	Allotments	Commercial/Industrial
H-3	1.E+5	5.E+8	1.E+5	8.E+9
C-14	2.E+5	1.E+7	2.E+5	3.E+7
K-40	5.E+3	1.E+4	5.E+3	6.E+4
Fe-55	4.E+6	2.E+7	4.E+6	9.E+8
Co-60	8.E+2	8.E+2	9.E+2	4.E+3
Ni-63	1.E+7	6.E+7	1.E+7	2.E+9
Se-79	4.E+3	2.E+6	4.E+3	1.E+8
Sr-90*	4.E+3	3.E+5	4.E+3	2.E+6
Nb-93m	3.E+7	4.E+7	3.E+7	5.E+8
Nb-94	1.E+3	1.E+3	1.E+3	6.E+3
Mo-93	1.E+5	6.E+6	1.E+5	5.E+7
Tc-99	2.E+3	6.E+6	2.E+3	2.E+7
Ag-108m*	1.E+3	1.E+3	1.E+3	6.E+3
Sn-121m*	2.E+6	4.E+6	2.E+6	3.E+7
Sn-126	7.E+4	8.E+4	7.E+4	4.E+5
Sb-125	5.E+3	5.E+3	6.E+3	2.E+4
I-129	6.E+4	2.E+5	6.E+4	2.E+6
Cs-134	1.E+3	1.E+3	1.E+3	6.E+3
Cs-137*	4.E+3	4.E+3	4.E+3	2.E+4
Pm-147	8.E+6	8.E+6	2.E+7	2.E+7
Sm-147	2.E+5	3.E+5	3.E+5	1.E+6
Sm-151	6.E+7	8.E+7	6.E+7	1.E+9
Eu-152	2.E+3	2.E+3	2.E+3	8.E+3
Eu-154	2.E+3	2.E+3	2.E+3	8.E+3
Eu-155	7.E+4	7.E+4	8.E+4	3.E+5
Pb-210*	1.E+3	5.E+3	1.E+3	2.E+5
Ra-226*	1.E+3	1.E+3	1.E+3	5.E+3
Ra-226^	3.E+01	3.E+01	3.E+01	2.E+02
Ra-228*	2.E+3	2.E+3	2.E+3	1.E+4
Ac-227*	3.E+3	3.E+3	3.E+3	1.E+4
Th-228*	1.E+3	1.E+3	1.E+3	6.E+3
Th-229*	5.E+3	5.E+3	6.E+3	3.E+4
Th-230	1.E+5	1.E+5	1.E+5	7.E+5
Th-232	8.E+4	9.E+4	1.E+5	5.E+5
Natural Th	2.E+3	2.E+3	2.E+3	9.E+3
Pa-231	2.E+4	2.E+4	2.E+4	7.E+4
U-233	6.E+4	3.E+5	6.E+4	3.E+6
U-234	6.E+4	3.E+5	7.E+4	3.E+6
U-235*	1.E+4	2.E+4	1.E+4	7.E+4
U-236	7.E+4	3.E+5	7.E+4	3.E+6
U-238*	4.E+4	7.E+4	4.E+4	4.E+5
Natural U	4.E+4	1.E+5	5.E+4	6.E+5
Np-237*	8.E+3	1.E+4	9.E+3	5.E+4
Pu-238	7.E+4	9.E+4	9.E+4	3.E+5
Pu-239	7.E+4	8.E+4	8.E+4	3.E+5
Pu-240	7.E+4	8.E+4	8.E+4	3.E+5
Pu-241*	5.E+6	6.E+6	6.E+6	1.E+7
Am-241	7.E+4	7.E+4	8.E+4	3.E+5

Note:

* include contributions from short-lived daughter radionuclides

^ includes an assessment of the potential exposure to the gaseous daughter of Ra-226, Rn-222

Appendix C : RCLEA User Guide

- C.1 A software application has been developed to accompany the RCLEA methodology. This provides a convenient implementation of the RCLEA models and data that can be used for generic and site-specific calculations. It has been implemented in Microsoft Excel® and is freely available as CLR 14 from the Environment Agency's contaminated land webpages at <http://www.environment-agency.gov.uk/research/planning/33746.aspx>.

System Requirements

- C.2 The RCLEA software application is designed to operate with Excel 2000 or later versions running on a Microsoft Windows® operating system. The file size is less than 1 MB and has no special memory, disk space or processor requirements beyond those of a modern personal computer. The application has a preformatted layout that is best viewed with a screen resolution of at least 1024 by 768 (XGA).
- C.3 RCLEA requires macros to be enabled in Excel. The macro settings can be changed in Excel by selecting **Tools|Macros|Security** – a 'Medium' level of security is recommended.

Using RCLEA in Excel

- C.4 RCLEA consists of a single workbook (.xls file) with a collection of worksheets (pages) that contain all input data and results. It is recommended that a copy be made of the RCLEA.xls file for each assessment. This copy should be renamed and saved regularly to capture any user defined input data.

For every parameter, a default library value is given (on a grey background), presented next to the user value (on a white background). All library values are protected against change. The underlying calculations are also hidden and protected. 'Generic' calculations only use library data, whilst 'Site Specific' calculations use the user specified data. Initially, all user values are set to equal the library values, however the user can modify most parameter values if required.

Box 1: Pages within the RCLEA Application

Name	Description
Intro	Gives RCLEA version information and space for application-specific information.
Instructions	General instructions for using RCLEA.
Main	The main calculation control page, which also presents a summary of results from the 'Doses' and 'GuidelineValues' pages.
Contamination	Allows the radionuclides of interest, average activity concentrations in contaminated soil and the fraction of soil that is contaminated to be specified.
Doses	Presents calculated doses for the scenario conditions that result in the highest total dose. Doses are presented for each radionuclide and pathway
All Doses	Presents a summary of total doses calculated for all combinations of calculation options considered. (Only displayed for a worst case calculation.)
Guideline Values	Presents Guideline Values - the radionuclide concentrations that would result in a dose criterion being reached.
Calculation Parameters	Summary of the parameter values used in the calculation of the highest radiation dose for the assessment.
Soil And Plant	Data describing soil properties relevant to contaminant behaviour.
Land Use	Land use specific data including exposure characteristics such as receptor occupancy, dust concentrations and skin contamination.
Building Type	Information on the assumed reduction in external irradiation dose rates due to shielding by building materials.
Human	Information describing human anatomical and physiological characteristics used in assessment calculations.
Consumption	Data on food ingestion rates and soil on home grown foods.
Effective Dose	Reference values that convert radionuclide intake into committed effective dose, or external irradiation by a given concentration to effective dose rate.
Equiv Dose	Reference values that convert and irradiation duration into equivalent dose to the skin.
New Land Use	Allows the user to define the basic characteristics of a user defined land use. (Only displayed when adding a new land use.)
Intermediate Calculations	Intermediate calculations undertaken by RCLEA.
Side Calcs	A spare page for any side calculations that are required.

- C.5 Many of the pages contain cells with comments that provide more information, help or tips. These can be viewed by hovering the mouse over the relevant cell.
- C.6 RCLEA contains pages of three types:
- ▲ Control and Information pages, which are coloured **green**;
 - ▲ Data input pages, which are coloured **yellow**; and
 - ▲ Calculation and results pages, which are coloured **blue**.
- C.7 When the RCLEA application is opened, the **Intro** page is shown. Other pages can be selected by clicking on the relevant tab. On some pages, buttons are provided to navigate to pages.
- C.8 All pages are designed to be printed onto A4 paper in landscape, although some pages are printed over several sheets.

Intro and Instructions Pages

- C.9 It is good practice to record basic details about the assessment on the **Intro** page. The Start button selects the **Main** page so that the assessment can be defined and run. The **Instructions** page contains some general advice on the use of RCLEA. It also contains any specific information relating to the latest version of the application.

Main Page

- C.10 The Main page is used to specify the calculation type and the main assumptions, undertake the calculation and to view a summary of the results.
- C.11 Selecting a **Generic** calculation uses default library data with the only exception being the user specified radionuclide(s) of interest and associated soil concentration(s). For a generic calculation the worst case can be sought among any or all of the categories - the code then identifies the combination of assumptions that leads to the highest dose.
- C.12 Selecting a **Site Specific** calculation enables user data to be used. A user-defined land use may be added by pressing the "Create New Land Use" button. Once created, the new land use name appears on the drop-down menu.
- C.13 Calculations only take a few seconds, and are undertaken by pressing the **Calculate** button. For calculations that require a worst case analysis, a progress

report is shown in Excel's status bar. Once the calculation is complete a summary of the results is presented.

Figure C: The RCLEA Main Page

The screenshot displays the 'Main' page of the RCLEA software. The page is divided into two main sections: 'Summary of Calculation Assumptions' and 'Summary of Results'.

Summary of Calculation Assumptions: This section includes a 'Calculation Type' selector with radio buttons for 'Generic' (selected) and 'Site Specific'. Below this are 'Calculation Selections' with dropdown menus for 'Land Use' (set to 'Worst'), 'Building Type' (set to 'Timber'), 'Receptor Age' (set to 'Infant'), and 'Receptor Sex' (set to 'Male'). There are 'Create New Land Use' and 'Calculate' buttons.

Summary of Results: This section shows 'Results from Last Calculation' at 09:06 on Wednesday, 21 Dec 2005. It specifies a 'Generic Calculation; Worst Case' scenario for 'Residential with Home-Grown Produce', 'Timber (fixed)', 'Infant (fixed)', and 'Male (fixed)'. The 'Total Dose' is 2.69E-03 Sv/y, and the 'Safety Margin' is 1.11. There are 'ViewDoses' and 'View GuideLine Values' buttons.

Reset All: A button in the top right corner.

Footnote: For Generic calculations, any Calculation Selection can be set to 'worst', and the option resulting in the highest dose will be reported. For Site Specific calculations only receptor age and sex can be set to determine the 'worst' as all other selections will be known.

Safety Margin: The ratio of the Effective Dose Criterion to the calculated Effective Dose.

RSRV: Guideline value for worst-case scenario. Note this value is not applicable to contamination with multiple radionuclides.

C.14 The **Main** page also contains a **Reset All** button. This resets user data on all pages to the default library values, sets the contamination to zero and removes any user-defined land uses.

Input Data Pages

C.15 The **Contamination** page is used to specify the activity concentration in soil for each radionuclide of interest. The check box next to the radionuclide name must be selected before the activity concentration can be entered. The fraction of land that is contaminated can also be set on this page. By default, it is assumed that all land is contaminated (=1). Patchy contamination can be represented by defining a fraction representing the ratio of the contaminated area to the area specified in the land use scenario. This page also gives the options on the method of calculating Rn-222 gas concentrations if Ra-226 has been selected. Either a measured value can be entered (in Bq m⁻³) or the concentration can be calculated.

C.16 RCLEA contains several other input data pages, containing user-editable data:

- ▲ **Soil And Plant** data;
- ▲ **Land Use** data;

- ▲ **Building Type** data;
- ▲ **Human** data; and
- ▲ **Consumption** data.

- C.17 In addition, non-user editable data is presented in the **EffectiveDose** and **EquivDose** pages.
- C.18 Modified user values (not equal to the reference values) are indicated by a green background. It is good practice to add a comment to indicate why a parameter has been changed from its reference value.
- C.19 New land uses can be added for site-specific calculations using the “Create New Land Use” button on the Main page. This selects the **NewLandUse** page.
- C.20 Each new land use must be based on an existing reference land use, entered on the **NewLandUse** page. This is used to define its library data values (the user values can, of course, be changed). The user can also select the relevant age groups and exposure pathways on the **NewLandUse** page. Pressing the “Add New Land Use” takes the user to the Land Use page, where the data can be reviewed and modified.

Results Pages

- C.21 The Doses page presents the results by radionuclide and pathway for the radionuclides that have been included in the assessment. The **GuidelineValues** page indicates the contamination levels that result in a dose criterion being breached based on a number of conservative assumptions.
- C.22 If a worst case calculation has been undertaken then the results displayed relate to the combination of assumptions leading to the highest dose (except for the **AllDoses** page which lists the total dose calculated for all combinations of calculation assumptions).
- C.23 Finally, the **CalculationParams** page summarises the data values used in a calculation.

Appendix D : Worked Example of the Application of RCLEA

Introduction

D.1 This appendix presents a hypothetical worked example of the use of RCLEA in the determination or elimination of land contaminated by radioactivity. Simplifications for this example include are as follows.

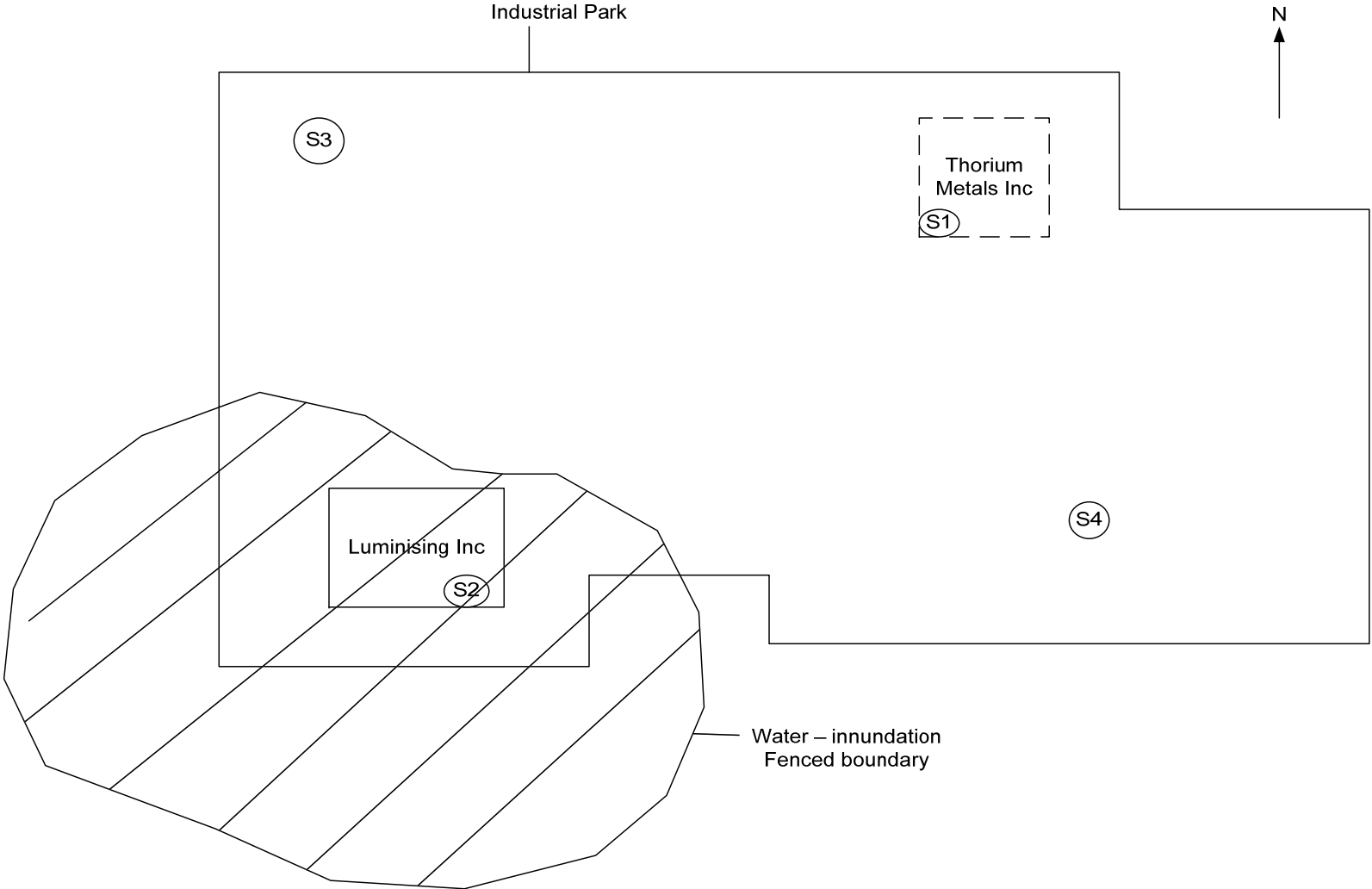
- ▲ It is assumed that all measurements and calculated doses are *in addition* to a contribution from natural background.
- ▲ The radionuclides quoted in this example are likely to be found with other radionuclides, as they are members of natural radionuclide decay chains. In addition, Uranium-238 will almost always be found in association with other uranium isotopes.
- ▲ It is assumed that the sample and analysis data are representative of an area around each sample point that is consistent with the land use areas assumed in RCLEA. Furthermore, it is assumed that each area is of sufficient size to be considered separately. In reality, more samples than discussed in the example would be required to determine the extent and level of contamination.

The Site

D.2 The worked example considers a hypothetical derelict former industrial site. Trade Directories show that two companies of possible interest occupied the site: Thorium Metals inc. and Luminising inc. Neither company can now be traced, both having ceased trading in the 1950s.

D.3 The site is now unoccupied, but access is possible for members of the public to some areas. Buildings in good condition remain on the Thorium Metals part of the site. In the SW corner, the area known to have been occupied by Luminising inc has been inundated by a river and has become marshland. The marshland area is securely fenced for safety reasons and public access is not possible. The site layout is shown in Figure D.

Figure D: Layout of the Hypothetical Site



- D.4 The Environment Agency has sent information to the Local Authority indicating that although the two companies ceased trading prior to controls being imposed under the Radioactive Substances Act 1960, radioactive material was handled by them. Some analytical data is available from soil samples obtained during an investigation by the Radiochemical Inspectorate in 1981. The measured concentrations of various radionuclides are presented in Table D.

Table D: Measured Concentrations of Radionuclides at Four Locations on the Site

Sampling Location	Th-232 (Bq/kg)	U-238 (Bq/kg)	Ra-226 (Bq/kg)
S1	200	1000	50
S2	500	1000	1000
S3	500	1000	200
S4	1000	1000	1000

- 3.15 Local Authority records show that, in 1988, the National Radiological Protection Board (NRPB) was asked to carry out radon surveys in various buildings on the derelict site. The NRPB report identified concentrations of 80 Bq/m³ in an enclosed building in location S1. The other buildings on the site are derelict and open to outdoor air, and radon concentrations were not distinguishable from the local background.

Initial Observations

- D.5 The former uses of the land ('past practices') appear in Defra's Historical Profiles series, and some are described as having the potential for determination as radioactively contaminated land.
- D.6 The U-238 contamination appears to be uniform across the site. It is possible that uranium ores were processed historically to separate radioactive isotopes of thorium and radium, which were then further processed by Thorium Metals inc. and Luminising inc. Thorium and radium contamination appears to be patchy, likely to be related with specific processing areas.
- D.7 Although the sample data are old (dating from 1981), all of the radionuclides concerned have very long half-lives and are not rapidly leached from soil. The

concentrations measured can therefore be considered to be representative of likely present-day values.

- D.8 Reference to the RSGVs for the closest appropriate Land Use (Commercial/Industrial) indicates that the sum of the ratios of each radionuclide to their respective RSGV exceeds 1 for locations S2 – S4 if Rn-222 is included, although it is lower than 1 for all locations if this is not included. . The site is therefore deemed worthy of further assessment.

Screening Calculations with the RCLEA Application

- D.9 Go to the RCLEA title page and enter the details of the assessment – assessor, site information, site description etc. Save this spreadsheet with a unique filename. It will need to have a number of versions – one version for each sample point, and different calculation runs for each sample point. Develop a hierarchy of identifiers with sub-numbers accordingly.
- D.10 On the CONTAMINATION page, tick the radionuclides to be assessed and enter the appropriate concentration values. For sample point 1 (S1), this looks like:

Contaminant Selection Specification of radionuclides of interest, average activity concentrations in contaminated soil and the fraction of soil that is contaminated. [Goto Main Sheet](#) [Reset](#)

Fraction of the land that is contaminated: Area considered in each land use: Residential = 0.2 ha
Allotment = 0.8 ha
Commercial/Industrial = 2 ha

Activity Concentration (Bq per kg dry mass of soil) Activity Concentration (Bq per kg dry mass of soil)

Radionuclide	Include?	Activity
H-3	<input type="checkbox"/>	0
C-14	<input type="checkbox"/>	0
K-40	<input type="checkbox"/>	0
Fe-55	<input type="checkbox"/>	0
Co-60	<input type="checkbox"/>	0
Ni-63	<input type="checkbox"/>	0
Se-79	<input type="checkbox"/>	0
Sr-90	<input type="checkbox"/>	0
Nb-93m	<input type="checkbox"/>	0
Nb-94	<input type="checkbox"/>	0
Mo-93	<input type="checkbox"/>	0
Tc-99	<input type="checkbox"/>	0
Ag-108m	<input type="checkbox"/>	0
Sn-121m	<input type="checkbox"/>	0
Sn-126	<input type="checkbox"/>	0
Sb-125	<input type="checkbox"/>	0
I-129	<input type="checkbox"/>	0

Radionuclide	Include?	Activity
Cs-134	<input type="checkbox"/>	0
Cs-137	<input type="checkbox"/>	0
Pm-147	<input type="checkbox"/>	0
Sm-147	<input type="checkbox"/>	0
Sm-151	<input type="checkbox"/>	0
Eu-152	<input type="checkbox"/>	0
Eu-154	<input type="checkbox"/>	0
Eu-155	<input type="checkbox"/>	0
Pb-210	<input type="checkbox"/>	0
Ra-226	<input checked="" type="checkbox"/>	50
Ra-228	<input type="checkbox"/>	0
Ac-227	<input type="checkbox"/>	0
Th-228	<input type="checkbox"/>	0
Th-229	<input type="checkbox"/>	0
Th-230	<input type="checkbox"/>	0
Th-232	<input checked="" type="checkbox"/>	200
Natural Th	<input type="checkbox"/>	0

Radionuclide	Include?	Activity
Pa-231	<input type="checkbox"/>	0
U-233	<input type="checkbox"/>	0
U-234	<input type="checkbox"/>	0
U-235	<input type="checkbox"/>	0
U-236	<input type="checkbox"/>	0
U-238	<input checked="" type="checkbox"/>	1000
Natural U	<input type="checkbox"/>	0
Np-237	<input type="checkbox"/>	0
Pu-238	<input type="checkbox"/>	0
Pu-239	<input type="checkbox"/>	0
Pu-240	<input type="checkbox"/>	0
Pu-241	<input type="checkbox"/>	0
Am-241	<input type="checkbox"/>	0

- D.11 As Ra-226 is included, RCLEA requires the user to specify how the Rn-222 gas concentration is to be calculated. For location S1, a measured value (80 Bq/m³) can be used.

D.12 Go to the MAIN page. With the Calculation Type set to 'Generic', and 'Worst' selected for each of the calculation selection, carry out a calculation.

D.13 For S1, the results are displayed on the MAIN page as follows:

Main Main calculation control page, which also presents a summary of results from the 'Doses' and 'Guideline Values' pages. Reset All

Summary of Calculation Assumptions

Calculation Type:
 Generic Site Specific

Calculation Selections:

Land Use: Create New Land Use

Building Type:

Receptor Age:

Receptor Sex:

Calculate

For Generic calculations, any Calculation Selection can be set to 'worst', and the option resulting in the highest dose will be reported. For Site Specific calculations only receptor age and sex can be set to determine the 'worst' as all other selections will be known.

Summary of Results

Results from Last Calculation:
 at 09:02 Friday, 13 May 2011

Generic Calculation; Worst Case

Residential with Home-Grown Produce
 Timber
 Infant
 Male or Female

Total Dose = 2.4 mSv/y

Safety Margin: 1.2

The land use and human habit assumptions should be checked to ensure that they are appropriately conservative for the site concerned.

ViewDoses ViewGuideLine Values

Safety Margin: The ratio of the Effective Dose Criterion to the calculated Effective Dose.

RSGV: Guideline value for worst-case scenario. Note this value is **not applicable** to contamination with multiple radionuclides.

D.14 The result is a potential dose of 2.4 mSv/year to an infant, assuming a residential scenario (with home-grown produce) and a timber-framed building.

D.15 Repeating the calculation for each sample point (in case of S2 – S4 setting the Rn-222 calculation to use the default coefficient, as no measurements are available), the same scenario assumptions lead to the highest doses, which are:

- ▲ S1: 2.4 mSv/year
- ▲ S2: 86 mSv/year
- ▲ S3: 17mSv/year
- ▲ S4: 86 mSv/year

D.16 The results for S1, within the footprint of the area formerly occupied by Thorium Metals Inc, indicate that although the area is not clear of contamination, the health protection criteria may not be exceeded. A further calculation assuming a specific Commercial/Industrial land use results in a dose of 0.5 mSv/year, well

below the criterion. On this basis, this area can be screened out from further consideration as radioactively contaminated land (assuming, as mentioned above, that the samples adequately represent the extent of soil contamination and radon concentrations in this part of the site).

- D.17 The results for S2 – S4 are significantly above the 3 mSv/year criterion contained in the Statutory Guidance. However, the results again correspond to a ‘Residential with home grown produce’ scenario, which assumes that the exposed individual is present all the time, and eats produce grown in the soil. This is not an appropriate representation of the use of the land.
- D.18 Re-calculation with a more appropriate land use (Commercial/Industrial) is still inconclusive, as the calculated doses range from 4 to 20 mSv/year. Nevertheless, these areas could be screened out from further consideration if the assessor considers that the buildings are derelict and Rn-222 concentrations are not above background, as the radionuclide dominates the calculated dose. However, this conclusion assumes that the buildings would not be repaired and re-occupied without planning permission. A Local Authority investigator will need to take a view on this prior to elimination. Furthermore, consideration should be given to the potential for exposures resulting from the migration of radionuclides in surface water.
- D.19 To illustrate this, a further screening check can be made for sample point 2. Reference to the CALCULATED DOSES page for this calculation indicates that, indeed, the majority of the dose is associated with the Rn-222 gas inhalation pathway. A more detailed radon survey would indicate the extent of the problem, and could be used to determine site-specific radon assessment parameters.
- D.20 Further examination of the area formerly occupied by Luminising inc. indicates that the water inundation has occurred as a result of the management of a nearby river. It is concluded that restoration of the land to a state usable for building would be a substantial undertaking that would require planning permission. Because there is no prospect for buildings in that area to be reused and occupied without this work, the exposure to radon indoors is not a relevant pathway. The maximum dose from other pathways is 0.6 mSv/year, and therefore the area is well below the dose criterion.

Calculated Doses Calculated doses for the scenario conditions that result in the highest total dose. Doses are presented for each radionuclide and pathway.

[Goto Main Sheet](#)

Calculation resulting in highest dose:

Land Use:	Commercial/Industrial
Building Type:	Timber
Receptor Age:	Adult
Receptor Sex:	Male

Pathway	External Whole Body Irradiation	Soil Ingestion	Skin: External Irradiation	Inhalation	Ingestion: Vegetables	Ingestion: Soil on Vegetables	Inhalation: Rn-222 Gas Indoors
Considered?	✓	✓	✓	✓	x	x	✓

Included: ✓
 Excluded: x

Radionuclide	External Whole Body Irradiation	Soil Ingestion	Skin: External Irradiation	Inhalation	Ingestion: Vegetables	Ingestion: Soil on Vegetables	Inhalation: Rn-222 Gas Indoors	Total	Skin: External Irradiation
Ra-226	5.75E-01	2.58E-03	4.38E-05	6.02E-04	0	0	1.87E+01	1.92E+01	1.04E-02
Th-232	1.33E-05	1.06E-03	3.49E-05	2.16E-03	0	0	0	3.26E-03	8.32E-03
U-238	6.96E-03	4.42E-04	2.73E-05	4.99E-04	0	0	0	7.92E-03	6.52E-03
TOTAL	5.82E-01	4.08E-03	1.06E-04	3.25E-03	0	0	1.87E+01	1.92E+01	2.53E-02
% Contribution	3.0	0.0	0.0	0.0	0.0	0.0	96.9	100.0	

Zero values are reported for pathways that are not considered in the calculation.

Determination Using the RCLEA Application

- D.21 A review of the literature suggests that industrial units are more highly ventilated than the default assumptions in RCLEA (a ventilation rate of once per hour compared with the assumption of 0.3 per hour).
- D.22 Modifying the ventilation rate parameter on page BUILDING TYPE and re-running the calculation, the result, reduces the dose for locations S3 and S4 to 1 mSv/year and 4.8 mSv/year respectively. On the basis of the buildings present, S3 can be screened out, but S4 remains above the 3 mSv/year threshold.
- D.23 At this stage, specialist advice should be sought to determine if any further refinements to the calculations (perhaps in ‘Site Specific’ mode) can be made, in particular those related to the calculation of Rn-222 concentrations. A further radon survey is likely to be appropriate. At this stage it may also be reasonable to consider whether other assumptions and parameters used in the generic calculations are appropriate for the current land use. Paragraph A43 of the Statutory Guidance defines “current use” for the purposes of the guidance; note in particular that the “current” land use includes future uses which do not require new or amended planning permission.
- D.24 If it is concluded that the assumptions adopted for the ‘Commercial/ Industrial’ land use scenario are appropriate to the location of S4, further investigation of

radon concentrations has been made, and all the requirements of the statutory guidance have been fully met, the area can be determined as radioactive contaminated land.

Main

Main calculation control page, which also presents a summary of results from the 'Doses' and 'Guideline Values' pages.

Reset All

Summary of Calculation Assumptions

Calculation Type:
 Generic Site Specific

Calculation Selections:

Land Use: Commercial/Industrial Create New Land Use

Building Type: Worst

Receptor Age: Worst

Receptor Sex: Worst Calculate

For Generic calculations, any Calculation Selection can be set to 'worst', and the option resulting in the highest dose will be reported. For Site Specific calculations only receptor age and sex can be set to determine the 'worst' as all other selections will be known.

Summary of Results

Results from Last Calculation:
at 10:06 Friday, 13 May 2011

Generic Calculation; Worst Case

Commercial/Industrial (fixed)
Timber
Adult
Male or Female

Total Dose = 4.8 mSv/y

Safety Margin: 0.62

A more detailed assessment of exposures is required, using site-specific information.

View Doses
View Guideline Values

Safety Margin: The ratio of the Effective Dose Criterion to the calculated Effective Dose.

RSGV: Guideline value for worst-case scenario. Note this value is **not applicable** to contamination with multiple radionuclides.

D.25 If the land is so determined, then remediation steps need to be considered. As a guide to possible remediation methods, the CALCULATED DOSES page shows how the various exposure pathways contribute to the calculated dose. In this instance, nearly 90% of the dose is attributable to radon. Therefore, in addition to direct removal of contaminated soil, alternatives such as the provision of some form of impermeable covering (e.g. covering the contaminated area with hardstanding) could be considered.

D.26 The analytical data available do not permit the extent of the contamination to be determined. In this case, a sampling and analysis programme extending out from around sample point 2 should be undertaken in order to delineate the area of radioactively contaminated land. The results from this programme can be used in RCLEA calculations to further refine the assessment of doses.