NUCLEAR INDUSTRY GROUP FOR LAND QUALITY

Industry Guidance

Qualitative Risk Assessment for Land Contamination, including Radioactive Contamination

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DOCUMENT REVISION RECORD

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FOREWORD

This guidance document was commissioned by the Nuclear Decommissioning Authority (NDA) as part of its Direct Research Portfolio (DRP). The specification for the document was prepared on behalf of NDA by Hugh Richards of Magnox Ltd. The document was prepared by Nick Hesketh and Mike Pearl of UKAEA Limited (now part of Babcock International Group) with input from Hugh Richards and support from Paul Nathanail of the University of Nottingham.

During its preparation, a number of industry and regulator stakeholders (including representatives of the Environment Agency (EA), Scottish Environment Protection Agency (SEPA), the Office for Nuclear Regulation (ONR), and the Local Authorities' Nuclear Legacy Advisory Forum) were consulted through workshops, correspondence and informal meetings.

Industry representatives consulted were drawn largely from what is now the Nuclear Industry Group for Land Quality (NIGLQ), formerly the "Inter-Industry Group on Contaminated Land Management and Site Restoration Issues" (IIG-CL). The "Land Quality R&D Working Group" of the NIGLQ also acts as a working group of the Nuclear Waste Research Forum and provides advice to NDA on the specification and acceptance of land quality work within the NDA DRP, including this work. It was subsequently decided that this guidance document should be published under the auspices of the NIGLQ.

This first approved version of the guidance is based upon an earlier "UKAEA Ltd Issue 3" version that was trialled at some sites during 2010/11 and subject to informal review and feedback from representatives of regulators. This version supersedes the earlier version and differs significantly in some respects.

Further revision of this guidance is anticipated, in particular to take account of the expected revised Statutory Guidance to the "Part 2A" contaminated land regime in England and Wales, any further review/comments from regulators, and feedback from users. However, the intent is that such further revision should be to add clarity rather than make substantive changes. Any feedback would be welcomed, and should be sent to research@nda.gov.uk, preferably before 1 November 2012.

Note that involvement of representatives of regulators during the development of this industry guidance should not be construed as evidence of regulator endorsement.

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A late draft of this document also benefited greatly from informal reviews by a number of land quality professionals from outside the nuclear industry, facilitated by the Society of Brownfield Risk Assessment (namely Kim Baines, Mike Carey, Simon Clennell-Jones, Simon Cole, Stephen Dooley, Naomi Earl, David Hall, Candida Lean, Richard Moss, Kevin Privett, Mike Ramsey, Peter Rostron, Catherine Scheib, Jennifer Stothert, Jeff Thornton and Clive Williams).

EXECUTIVE SUMMARY

The purpose of this document is to provide a methodology for qualitative risk assessment (Q_LRA) of land contamination. It covers both non-radioactive and radioactive contamination and considers the full range of receptors (i.e. people, the environment and property) for land contamination in its current condition or a planned future condition.

This guidance is aimed mainly at land quality management practitioners in the nuclear industry but may also be applicable to potentially contaminated sites in other contexts.

As recommended in generic Government guidance on environmental risk assessment, Q_LRA for land contamination in this guidance is a structured process whereby qualitative assessments of the **Severity** (magnitude) of potential consequences for receptors from exposure to contaminants are combined with qualitative or semi-quantitative assessments of the **Likelihood** (probability) of such consequences, in order to arrive at a description of the relative **Significance** of the risks posed by the contamination.

The Severity descriptors presented in this document have been derived by building on pre-existing guidance developed by or for a variety of national agencies. These pre-existing guides address most types of receptor but do not consider radiological aspects or risks to any relevant compliance boundaries. Most of the terminology used here is derived from and broadly consistent with the pre-existing guidance, which has either been endorsed by an appropriate regulator (Environment Agency) or has been widely used by the Government agency (Ministry of Defence) with the largest holdings of land potentially affected by contamination in the UK.

The Severity descriptors are based on a general approach of defining “Severe” to mean a consequence that could not unreasonably be expected to lead to formal regulatory action (e.g. “Part 2A” determination) or other legal action by a regulator or affected party.

This guide also provides quantitative definitions of Likelihood that are broadly consistent with the pre-existing guidance, with the addition of an “Extremely Unlikely” descriptor to take account of the tendency in the nuclear industry to consider very low probability, high consequence events.

The matrix of Severity and Likelihood that defines “Significance” of risk in this guide is similar to those presented in pre-existing guidance.

It is strongly recommended that the definitions for Severity, Likelihood and Significance are appended to reports making use of this methodology, so that readers of such reports are aware of the methodology and definitions used.

Regardless of assessed Severity of consequence and Likelihood (and hence Significance), users of this guidance should always take account of the principles of keeping radiological risks “As Low As Reasonably Practicable” (ALARP) or “As Low As Reasonably Achievable” (ALARA – i.e. optimised).

This guide can be applied both to current site conditions and to planned conditions that may exist in the future. In either case, the user is prompted to consider whether risks that exist at the outset may change in the longer term, in the absence of any managed changes to site conditions. This guide is not intended for assessment of risks associated with disturbing land contamination for investigation, remediation or site development purposes.

This document concludes with some general commentary on how risks assessed using this methodology compare with “unacceptable” risks in the context-specific sense used in current national guidance on management of (non-radioactive) land contamination.

Users of this industry guide should be aware that it has not been endorsed by regulators, although some aspects of it build upon pre-existing regulator-endorsed guidance.

Contents

1 Introduction

1.1 Purpose

The purpose of this document is to provide a methodology for qualitative risk assessment (Q_LRA) of land contamination. It covers both non-radioactive and radioactive contamination and considers the full range of receptors within applicable regulatory regimes (i.e. people, the environment and property) for land contamination in its current condition or in a planned future condition.

This guidance is aimed mainly at land quality management practitioners in the nuclear industry but may also be applicable to potentially contaminated sites in other contexts.

1.2 Intended Users

This guide is intended primarily for use by experienced land quality risk assessment practitioners. As discussed in Section 2.5, Q_LRA should be undertaken by or under the supervision of professionals who are experienced in both qualitative and quantitative land quality risk assessment. The guidance can be used by individual land quality risk assessment practitioners or by expert panels led by such practitioner(s).

In addition, some of the contents of this document (e.g. Sections 1.4 and 1.5) are intended to help explain Q_LRA to a wider audience, and Section 3 contains guidance on what may be considered to be "unacceptable" risks, and what types of action might follow a Q_LRA.

1.3 Context

In respect of many environmental matters, the UK adopts a risk-based approach to preventing or minimising environmental damage or loss, and the protection of human health. This generic approach to environmental management is emphasised in the high level Government guidance document "Guidelines for Environmental Risk Assessment and Management" (DETR, EA & IEH, 2000), which is commonly known as "Greenleaves II".

1.3.1 Greenleaves II and III

Greenleaves II (DETR, EA & IEH, 2000) provides a framework for the development of functional technical risk assessment guidance by regulators for specific sector guidance such as contaminated land and waste management. It is a revised version of the 1995 publication "A Guide to Risk Assessment and Risk Management for Environmental Protection" (DoE, 1995), known as "Greenleaves I", which represented one of the first attempts to explore some of the underlying principles of assessing environmental risk.

Just prior to finalising this guidance, Greenleaves II was replaced by Greenleaves III (Defra, 2011) with the purpose of providing guidance that is in line with current thinking in the field of environmental risk management in England and Wales. The terminology used has changed but is not substantially different from that in previous versions. Since this guidance builds on other guidance that was based on the Greenleaves II framework, only a very limited attempt has been made to align with Greenleaves III.

The scope of this guidance corresponds to the "Formulate Problem" and "Assess Risk" stages of the Greenleaves III Framework.

1.3.2 Pre-existing guidance on risk assessment for land contamination

Guidance on risk assessment for land contamination applicable to the UK and broadly consistent with the "Greenleaves II" framework has been developed by CIRIA (2001), EA

(2004), NHBC/EA/CIEH (2008) and CIRIA (2009). Guidance specific to the MoD estate has also been developed (Defence Estates, 2007). The Q_LRA guides contained within NHBC/EA/CIEH (2008) and Defence Estates (2007) are based on CIRIA (2001). The present guidance document seeks to build on and in some cases improve upon this pre-existing guidance, addressing specific needs of the nuclear industry.

1.4 What is qualitative risk assessment for land contamination?

As recommended in the Department of the Environment, Transport and the Regions (DETR) "Greenleaves II" guidance, Q_LRA for land contamination is a structured process whereby qualitative assessments of the **severity** (magnitude) of potential consequences for receptors from exposure to contaminants are combined with qualitative or semi-quantitative assessments of the **likelihood** (probability) of such consequences, in order to arrive at a description of the relative **significance** of the risks posed by the contamination.

As such, Q_LRA is widely used as the first step in assessing a potentially contaminated site, when quantitative information may be limited or lacking.

In particular, Preliminary Q_LRA is the first step of the "CLR-11" tiered approach for assessing risks associated with land contaminated by non-radioactive contaminants (EA, 2004):

- Tier 1: Preliminary (Qualitative) Risk Assessment;
- Tier 2: Generic Quantitative Risk Assessment (assessment of representative contaminant concentration data with respect to generic assessment criteria); and
- Tier 3: Detailed Quantitative Risk Assessment (assessment of representative contaminant concentration data with respect to site-specific assessment criteria).

Each successive tier of risk assessment is intended to be more realistic (less conservative) and therefore requires more information to support it. Later tiers of risk assessment are needed where it is not clear whether or not unacceptable risks are present. As discussed in Section 1.6, Q_LRA may be used more than once in a land quality risk management process, not just at the preliminary "Tier 1" stage.

In Section 2.2 of CLR-11, Tier 1 is termed "Preliminary Risk Assessment", and its stated purpose is "to develop an initial conceptual model of the site and establish whether or not there are potentially unacceptable risks". The key phrase here is "potentially unacceptable risks", which is context-specific[1] and discussed further in this document. CLR-11 does not contain a Q_LRA methodology.

Tiered risk assessment is also the recommended method for managing radioactive and non-radioactive land contamination on nuclear licensed and defence sites in the main SAFEGROUNDS land contamination management guidance (CIRIA, 2009). Section 3.3.1 of the SAFEGROUNDS guidance calls Tier 1 Q_LRA "preliminary safety & environmental risk assessment", and states its purpose as: " … a preliminary qualitative risk assessment … for what appears at this stage to be important areas of potential contamination …" Unfortunately, this implies that some sort of prioritisation of areas of potential contamination has taken place before Q_LRA commences, whereas Q_LRA actually should be an input to prioritisation. The SAFEGROUNDS guidance does not contain a Q_LRA methodology.

[1] It is important to recognise that the context-specific meanings of "unacceptable risks" envisaged in CLR-11 potentially relate to a wide variety of receptors, and should not be assumed to be consistent with the Health and Safety Executive's (HSE) meanings of "broadly acceptable", "tolerable" and "intolerable" risks to people (HSE, 2001a).

Guidance endorsed by the EA and others (NHBC/EA/CIEH, 2008) does include an outline methodology for Q_LRA. That guidance (referred to here as "R&D66:2008") was developed to focus particularly on the development of housing on land affected by contamination, but the Q_LRA methodology it contains (in Section 1.7 of Volume 1 and Annex 4 of Volume 2) is applicable to other forms of development and to existing land uses. Volume 1 of R&D66:2008 recommends a tiered approach to risk assessment broadly consistent with CLR-11. The Glossary of R&D66:2008 defines "Preliminary Risk Assessment" as "the first tier of risk assessment that develops the initial conceptual model of the site and establishes whether or not there are any potentially unacceptable risks" (i.e. consistent with CLR-11).

The DETR "Greenleaves II" guidance on generic environmental risk assessment calls the first tier of risk assessment "risk screening" and importantly provides a sequential risk assessment process (from "hazard identification" through "risk estimation" to "risk evaluation") that forms the basis of the Q_LRA methodology presented here (see Section 2.2).

1.5 Q_LRA as an input to risk management

The key outputs of the Q_LRA methodology presented here are qualitative descriptors of the **significance** of risks to different receptors associated with particular areas of known or potential contamination, ranging from "Trivial" to "Very High"[2]. Describing risks in this way (using a "common dictionary") helps to prioritise land quality management activities within and between sites.

Once Q_LRA has been completed, the question arises as to whether "unacceptable risks" (in the very broad sense envisaged in CLR-11) are potentially present. What represents an "unacceptable risk" is context-specific, and should be determined by the stakeholders involved in managing the problem. However, it is useful for problem-holders to have some guidance on the following:

- What are considered as reasonable interpretations of "unacceptable risks"?; and
- What generic types of action are considered reasonable expectations following identification of risks of given significance?

The R&D66:2008 guidance contains some broad guidelines relevant to the above, but these are not considered sufficiently comprehensive for contexts where resources have to be prioritised over a diverse portfolio of sites and over diverse land contamination issues within individual sites. This document offers somewhat more detailed guidance (in Section 3 and Appendix 3) on what types of action might follow a Q_LRA.

1.6 Intended scope of application

This guidance is intended to be used primarily for assessing risks to a variety of receptors (people, the environment and property) from land contamination in its current condition or a planned future condition.

Unlike other available Q_LRA guidance, this methodology allows for assessment of risks of non-compliance for aspects of regulation involving a well-defined "compliance boundary" which can be considered as a "receptor". An example might be the risk of discharge of radioactivity from a nuclear site by a route other than stipulated within the site's Environmental Permit under the Environmental Permitting (England and Wales) Regulations 2010 (EPR10) or Authorisation under the Radioactive Substances Act (RSA93) in Scotland.

[2] It is important to recognise that no claim is made that there is parity of risk descriptors between receptors. For example, no claim is made that a "Very High" risk to the water environment can be compared with a "Very High" risk to human health.

Although Q_LRA is particularly needed for the first (preliminary) tier of risk assessment, it can be applied at any stage, especially if there is a need to assess risks consistently on a site-wide basis, covering Areas of Potential Concern (APCs) that may be at different stages of characterisation and assessment. Repeated application of Q_LRA during a multi-year programme of land quality management (such as exist on many nuclear sites) may also be used to monitor progress in risk management.

This guidance is not intended for assessing risks associated with undertaking planned work that may affect or be affected by land contamination. The assumption is being made that suitable and sufficient risk assessments for such planned work will be required under the site operator's procedures.

In the context of managing radioactive land contamination on a nuclear licensed site, the Q_LRA methodology presented here is potentially valuable in helping to identify and prioritise further actions, but it has limitations. In particular:

- It does not provide a basis for determining requirements for radiological controls to limit doses to on-site personnel under the Ionising Radiations Regulations 1999 (IRR99). This is covered by arrangements appropriate to a nuclear licensed site;
- It does not provide a basis for assessments as to whether reasonably practicable controls may be warranted solely to minimise spread of radioactive land contamination within the licensed site boundary[3]. This is because such spread of contamination does not of itself necessarily lead to increased risks to receptors that are within the scope of Q_LRA;
- It does not provide a basis for BAT/BPM assessments of radioactive wastes (solid, liquid or gaseous) arising from management/remediation of radioactive land contamination within the licensed site boundary. Again, this is covered by arrangements appropriate to a nuclear licensed site;
- It is not intended to be used as a key part of a process to develop a safety case for radioactive land contamination on the licensed site. In particular, it is not intended to be used in the context of assessment of potential accident conditions affecting radioactive land contamination (whether caused by external hazards, internal hazards or fault conditions). Again, arrangements for the production of safety cases will already exist for a nuclear licensed site; and
- It is not intended to be used as part of a process to develop a case for de-licensing of part or all of a licensed site. This is primarily because the main risk criterion for de-licensing is quantitative.

The Q_LRA methodology presented here does not address project, financial or reputational risks.

1.7 Structure of the guidance

Section 1 outlines the purpose of the guidance, how it has been developed, the background to Q_LRA, and what it is expected to achieve. Section 2 presents the methodology for Q_LRA, and Section 3 discusses how the outcomes of Q_LRA may be interpreted. A Glossary of acronyms/abbreviations is provided in Section 4 and References are in Section 5. The Appendices are referenced from specific points in Sections 1 to 3.

[3] e.g. demonstration whether Licence Condition 34 concerning containment of radioactive material/waste and detection of leakage/escape (spread) of contamination is being met, "so far as is reasonably practicable".

1.8 Definitions

To avoid misunderstandings in the use of the guidance a number of the terms used in the guidance need to be defined. These are:

- **Areas of Potential Concern (APC)** – Areas of land identified (while undertaking desk studies / site investigations) as having been or are subject to a land use that may give rise to contamination (CIRIA, 2001).
- **Contamination** – "Presence of a substance or agent, as a result of human activity, in, on or under land, which has the potential to cause harm or to cause pollution. (*NOTE There is no assumption in this definition that harm results from the presence of the contamination)*" (BSI, 2011)[4].
- **Environment** – consists of all, or any, of air, water and land (Environmental Protection Act 1990 (EPA90)). The environment includes land, water (including groundwater), air, flora, fauna, buildings, non-human biota, crops and sites of historical importance (CIRIA, 2009)[5].
- **Groundwater** – all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil (Water Framework Directive 2000/60/EC Article 2(2)).
- **Harm** – harm to the health of living organisms or other interference with the ecological systems of which they form a part and in the case of man, includes harm to their property (Section 78 EPA90 Part 2A) (CIRIA, 2001).
- **Hazard** – a property or situation that in particular circumstances could lead to harm (DETR, 2000).
- **Pollution** – the direct or indirect introduction, as a result of human activity, of substances or heat into the air, water or land which may be harmful to human health or the quality of aquatic ecosystems or terrestrial ecosystems directly depending on aquatic ecosystems, which result in damage to material property, or which impair or interfere with amenities and other legitimate uses of the environment (EC, 2000).
- **Receptor** - something that could be adversely affected by a contaminant, for example a person, an organism, an ecosystem, a piece of property, or a water body (Defra, 2006). See Table 1 for more details.
- **Risk** – In this document, "risk" is the combination of the probability (frequency) of occurrence of a defined hazard with the magnitude[6] of the consequences of the occurrence (DETR, 2000).
- **Risk assessment** – the formal process of identifying, assessing and evaluating the health and environmental risks that may be associated with a hazard (EA, 2004). (Other risks may also be present, such as reputational and business risks, but these are not considered in the context of this document).

Note that acronyms/abbreviations used are explained in the Glossary in Section 4.

[4] Note that this definition differs from the statutory definition of contaminated land under Part IIA of the Environmental Protection Act 1990, and that the text in italics forms part of the definition in BSI (2011).
[5] The "Environment" in this context is a short-hand for the setting in which non-human receptors are located.
[6] Probability and Magnitude have the same meaning as Likelihood and Severity respectively, as used in this guidance.

1.9 Legislative context

The guidance is primarily intended to be applicable to sites in England, Scotland and Wales. A summary of the legislative context is described in Appendix 1. A more detailed description is found in the SAFEGROUNDS “UK Regulatory Framework” paper (CIRIA, 2010), which may be updated from time to time.

Legislation changes from time to time. At the time of writing, changes to the statutory guidance underpinning Part 2A of the Environmental Protection Act in England and Wales and to the advice underpinning the planning regime in England are anticipated. These changes may alter some of the language adopted in this guidance. However, they are not expected to alter the basic principles upon which this guidance has been developed.

2 Description of Qualitative Risk Assessment Methodology

2.1 Pre-Assessment Stage

Prior to carrying out any assessment of land contamination, it is important to ensure that the problem has been adequately formulated and to collate relevant existing information (including any quantitative data or previous assessments that may inform the Q_LRA). Usually some form of land quality desk study that collates relevant information and identifies APCs should be available or in production, prior to undertaking Q_LRA. The desk study can then provide a key supporting reference to the Q_LRA.

The pre-assessment stage of Q_LRA involves clearly defining the context of the problem and setting the objectives of the assessment (EA, 2004, SNIFFER, 2007, CIRIA, 2009). Setting these out in a documented statement will help the problem holder support their risk management rationale during dialogue with regulators, funders and other stakeholders.

It is envisaged that this statement will include:

- the business and/or regulatory context for carrying out the risk assessment;
- the applicable regulatory regime(s);
- any decisions to be taken that the risk assessment process will inform;
- stakeholders to the decisions;
- the physical and temporal boundaries to the assessment;
- the current condition of the site, and its environmental setting;
- controls (including site-wide and APC-specific arrangements) that are already in place that mitigate risks from land contamination;
- the conceptual site model(s) for the APCs being assessed;
- the technical approach to carrying out risk assessment; and
- the existing arrangements to manage land contamination at the site.

The business/regulatory contexts for carrying out risk assessment may range from pro-active land quality management (on a site-wide or portfolio basis), through planning for site re-development to dealing with actual or threatened regulatory enforcement action.

The current condition of the site, the environmental setting and any site-wide aspects of the **conceptual site model** (CSM) are best represented as a series of diagrams, maps, cross sections and other diagrams (as appropriate to the site conditions) showing:

- the general features of the site setting, showing the context within which the site is located;
- the general features of the site including its boundaries and its surface morphology;
- the location of buildings on the site (including their current and past use where known);
- information on superficial deposits and solid geology;
- information on drainage features;
- information on the water environment (which includes the depth to water table, groundwater flow direction, water bodies on and adjacent to the site e.g. lakes and seas, water courses on and adjacent to the site e.g. streams and rivers);
- information on prevailing wind directions (both “average” direction and “strongest” direction) for identifying areas that may be contaminated via air-borne releases; and
- location-specific receptors on and adjacent to the site (e.g. location-specific sensitive human receptors such as farmers, school children, protected habitats, other sensitive environmental receptors and groundwater and surface water bodies).

APCs identified during the hazard identification stage of Q_LRA described below can then be superimposed onto the maps, sections and diagrams produced during problem formulation.

An essential part of problem formulation is the development of a preliminary CSM, as described in Section 2.3. This is formed by the combination of the environmental setting with hazard identification and hazard assessment (both of which are discussed in Section 2.4).

2.2 Stages within the Qualitative Risk Assessment

The DETR (2000) "Greenleaves II" framework recommends four stages of risk assessment within a Q_LRA, namely: hazard identification, hazard assessment, risk estimation and risk evaluation. Similar stages are also recommended in this document, with the additional consideration of whether the risks from radioactive land contamination are ALARP[7]. The stages are described below:

- Hazard identification – establishing the potential contaminants of concern (i.e. substances that in particular circumstances could lead to harm) for particular APCs, and where the contamination originates from;
- Hazard assessment – analysing the consequences that may arise from any given hazard which are inherent to the hazard (e.g. exposure to radioactivity). That is, what pathways and receptors could be present, and what pollutant linkages could be present;
- Risk estimation - estimating the magnitude/severity and probability/likelihood of the consequences. This considers how much of the substance reaches the receptor, what is the possible consequence (degree of harm or pollution), what is the potential magnitude of the effect and how likely is it;
- Risk evaluation - deciding the significance of the risk and whether it is unacceptable (relative to a specific legislative regime or decision making context) and (in the case of radioactive land contamination) ALARP[8].

Examples of receptors which might be impacted from contamination on and adjacent to nuclear sites are given in Table 1, and examples of the pathways by which some of these receptors might be exposed to or affected by contamination are given in Table 2.

[7] "ALARP" is a term used by the HSE (including ONR) and is particularly applied to radiological risks associated with nuclear licensed sites. For risks associated with radioactive land contamination not on nuclear licensed sites, the principle tends to be expressed in terms of "optimisation" of radiological risks and making such risks "ALARA". ONR's Safety Assessment Principles (HSE, 2006) state that "ALARP is also equivalent to the phrase "as low as reasonably achievable" (ALARA) used by other bodies nationally and internationally." In the remainder of this document, the term "ALARP" is used as short-hand for minimising radiological risks associated with radioactive land contamination.

[8] The ALARP assessment should consider whether proportionate additional controls are needed to justify that risks are ALARP taking into account economic and social factors (i.e. any further reduction in the risk can be achieved only at a grossly disproportionate cost that would outweigh the benefits afforded by the risk reduction).

Table 1: Potential Receptors On, and Adjacent to, Nuclear Sites

Receptor – something that could be adversely affected by a contaminant; for example a person, an organism, an ecosystem, a piece of property, or a water body. For assessment of risks in the future, different receptors may need to be considered, depending on the assumed uses of the land. Typical receptors that might be present are listed below:

- **Human**
  - Contaminated area workers: Those workers, who because of the nature of their work, or location of their work, are most likely to be affected by the contamination under the site conditions being assessed.
  - General on-site workers.
  - Visitors to the site[9].
  - Workers on an adjacent site (where two sites directly adjoin each other)
  - Off-site members of the public (people using land adjacent to the site, potentially including adults, children and infants).
- **Environmental**
  - Surface water (including coastal water, if present).
  - Groundwater.
  - Potable abstractions.
  - Protected non-human biota, such as Protected Species.
  - Protected habitats and ecological systems, such as a Site of Special Scientific Interest, National Nature Reserve, Special Protection Area for birds or wetland of international importance (RAMSAR site)[10].
- **Property**
  - Built environment (including buildings and underground services/structures).
  - Crops, livestock, wild animals which are subject to shooting or fishing rights.
  - Features of historical/archaeological importance.
- **Other**
  - Any relevant compliance boundary.

[9] Risks to visitors to the site should be less than those to general on-site workers, and therefore would not usually be assessed separately.

[10] Wildlife and Countryside Act 1981 and Conservation of Habitats and Species Regulations 2010.

Table 2: Examples of How Receptors Might be Exposed to, or Affected by Radioactive and Non-Radioactive Contamination via Various Transport Mechanisms and Exposure Pathways

Receptor	Example Consequence/ Impact	Example Transport Mechanism(s)	Exposure Pathways Leading to Consequence/ Impact
Human (on-site worker)	Incurring radiation dose by occupying buildings which overlie radioactive land contamination.	• Direct exposure from radiation modified by attenuation from clean soil cover and/or building floor slab.	• Direct exposure from external radiation.
Human (on-site worker)	Incurring radiation dose by walking on buried radioactive land contamination.	• Attenuation of radiation by soil cover.	• Direct exposure from external radiation.
Human (on-site worker)	Incurring health risk by excavating potentially contaminated soils not recognised as such.	• Direct exposure. • Transfer of soil to hands. • Windblown dust.	• Direct exposure from external radiation. • Ingestion of soil from hands. • Inhalation of dust.
Human (off-site public)	Incurring health risk by eating crops, meat or dairy products which are raised on off-site land impacted by contamination.	• Migration of contamination off-site in surface water run-off and/or dust. • Use of contaminated groundwater for irrigation. • Uptake of contaminant from soil into crops/fodder. • Uptake into livestock. • Contaminated soil collected with crops.	• Inhalation of dust. • Ingestion of crops. • Ingestion of meat or dairy products. • Ingestion of soil on unwashed crops.
Property (crops/ livestock)	Damage to crops/livestock.	• As above for health risk from contaminated agricultural land.	• Financial loss associated with inability to sell contaminated produce or breed from affected livestock.
Human (off-site public)	Working on off-site land impacted by contamination from the nuclear site.	• Migration of contamination off-site in surface water run-off and dust. • Use of contaminated groundwater for irrigation. • Personal contamination (e.g. hands & face) by direct contact with contaminated soil. • Dust raised by work activity (e.g. ground-works, ploughing).	• Inhalation of dust. • Ingestion of soil during work activities.
Ground-water	Impact to groundwater quality.	• Infiltration of rain water through contaminated ground. • Desorption of contamination from solid substrate into infiltrating water. Infiltration through the unsaturated zone to the saturated zone and impact to groundwater.	• Impact to groundwater quality (groundwater is a receptor for non-radioactive contaminants).
Surface Water	Impact to surface water quality.	• Overland flow of water across contaminated land. • Desorption of contamination from solid substrate into water. • Removal of particulate bound contamination from the solid substrate into water.	• Impact to surface water quality.
Property	Damage to sub-surface infrastructure.	• Migration of non-aqueous phase organic solvent contamination in ground.	• Damage to plastic pipes. • Contamination of potable water supply. • Damage to electrical insulation of cables.
Protected location (e.g. wetland)	Migration of contamination in surface water, groundwater and dust.	• Contamination migrates in surface/ground water to the protected site. • Accumulation of contamination in land, sediments and in ecosystem food web.	• Impact to the functioning of the ecosystem in the protected location (e.g. changes in populations of key species).

2.3 Conceptual Site Model

A conceptual site model (CSM) presents the relationships between the contaminant sources, pathways and receptors in written, tabular, plan, cross-section and/or other visual forms. The level of detail required in the CSM will differ depending on the complexity of the site (e.g. the geology, hydrogeology, hydrology and the diversity of types and origins of the potential contaminants of concern) and the level of detail of available information. The CSM should report uncertainties that impact on decision making (see Table 3).

In the process of hazard assessment the CSM will also incorporate environmental setting information collected at the problem formulation stage.

Typically a site-wide hydrogeological CSM, including cross-sections, will be developed which supports the assessments of risks to the water environment and/or risks to other receptors mediated by groundwater pathways. For some parts of a site, where, for example there may be complex geology and hydrogeology, or where particular features of the environmental setting cause complex interactions with the contamination, specific hydrogeological CSMs may also need to be produced. CSMs for other types of pathway may need to be developed for each APC, although they may be quite simple. The important point is to ensure that the CSM being used is valid for the particular APC and contaminant source-pathway-receptor linkage being assessed.

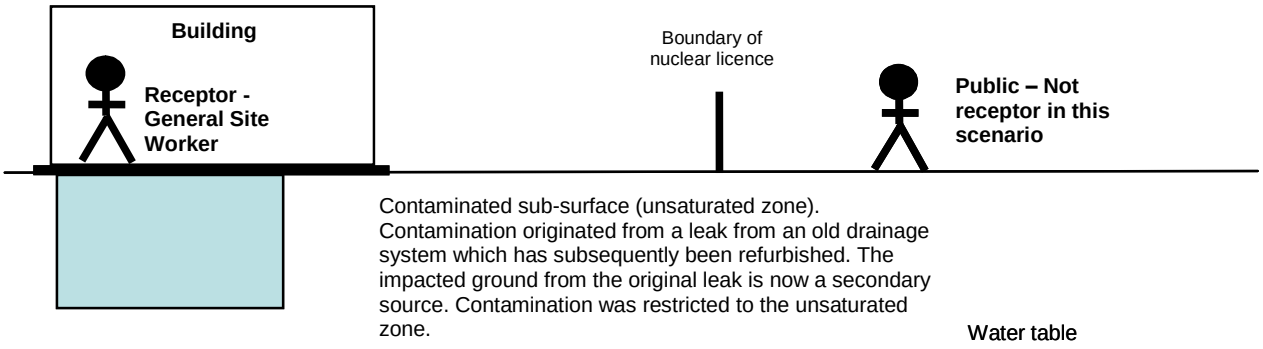
An example of the value of the CSM to the Q_LRA process is shown in Figure 1. In the scenario shown in Figure 1 (i), a particular event in the past caused a leak of radioactive contamination that impacted the ground below a building. The contamination from this leak was restricted to the unsaturated zone. Unless disturbed, the main receptors are on-site workers where the exposure pathway is by direct irradiation. In Figure 1 (ii), the past leak impacted the saturated zone and some of the radionuclides have subsequently migrated off-site in groundwater. The groundwater is then being used to irrigate crops. Thus a greater number of receptors are potentially impacted.

These simple scenarios not only illustrate the importance of the CSM, but also the need to ensure that the person carrying out the risk assessment considers the total environmental setting of the contamination, not just its local setting (i.e. not just the vicinity of the building and the risks to on-site workers within the building).

Figure 1: CSM and Exposure Scenarios for Similar Occurrences of Land Contamination

Scenario (i) Contamination restricted to unsaturated zone.
Receptors currently potentially at risk:

- general site worker in the building (but the base slab attenuates the dose)



Scenario (ii) At the time of the original leak, contamination reached the saturated zone.
Even though the leak was subsequently abated, there are pathways to the environment and to other human receptors from residual contamination.

Receptors currently potentially at risk:

- general site worker in the building (but the base slab attenuates the dose)
- groundwater below the site
- the nuclear licensed site boundary if considered as a "compliance boundary" type of receptor – at risk from contaminated groundwater migrating off-site
- public walking in fields outside the site boundary – inhalation of from dust blown from soil which has been irrigated with contaminated groundwater
- farmer – by external radiation, inhalation and ingestion associated from soil which has been irrigated with contaminated groundwater
- other public and farmers family – from ingestion of crops grown on, or animals grazed on, soil which has been irrigated with contaminated groundwater

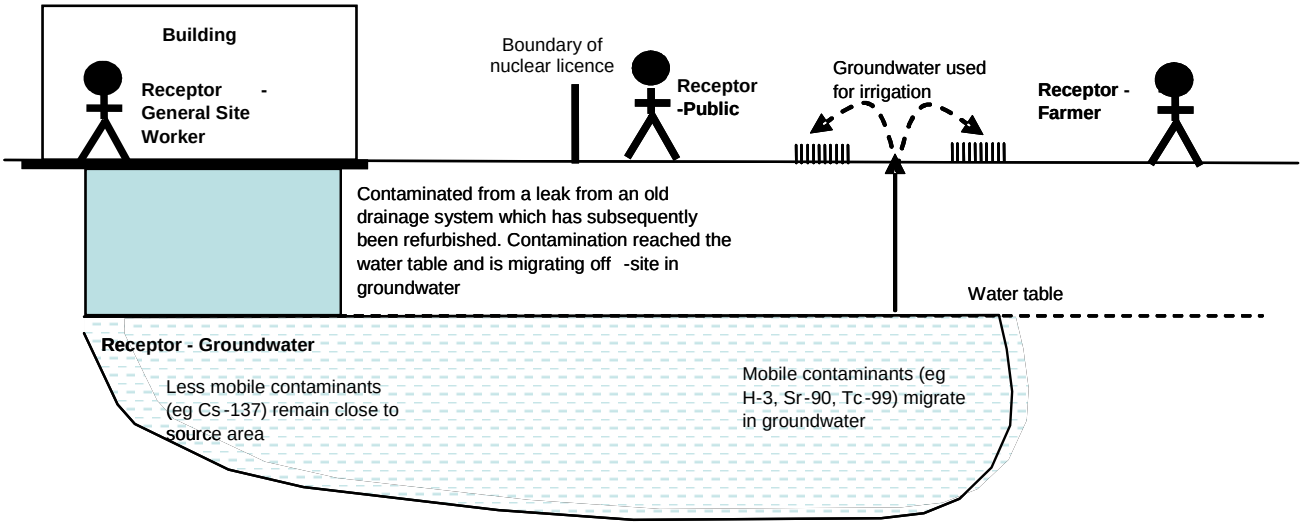


Table 3 provides a non-exhaustive check-list of items in a preliminary CSM. Depending on the nature of the site and potential for contamination, not all items listed may be needed, and for a first iteration of Q_LRA, some information may not be available.

Table 3: Preliminary Conceptual Site Model Checklist

- **The environmental context of the site**
  - Site layout (taking into account surface and sub-surface structures, including those owned or the responsibility of other organisations e.g. utility facilities that may cross under the site.
  - Site boundaries with respect to ownership, regulatory oversight, and access controls e.g. boundaries of radiological areas designated under the IRR99, boundary of the nuclear site licence, and boundary of the site relative to the current owner (which may include land outside the licensed boundary).
  - Topography (including any identified or ongoing landscape changes, such as coastal erosion).
  - Site history via site records, historical mapping etc.
  - Near surface and sub-surface soils and geology (including characteristics that may retard contaminant migration or accelerate contaminant migration).
  - Hydrogeological regime (groundwater is a receptor in its own right).
  - Surface water drainage (natural and man-made), including details of any design provisions (to deal with 1:100 storms, climate change adaptation plans, etc.).
  - Identification of watercourses (e.g. streams and rivers) and their quality status.
  - Presence of perched groundwater and depth.
  - Depth to groundwater bodies (and temporal variation).
  - Groundwater flow direction (and temporal variation).
  - Groundwater resource designation (e.g. Principal Aquifers, Secondary Aquifers or Unproductive Strata in England and Wales).
  - Identification of, and distance to the nearest private or public abstraction point, and any Source Protection Zone.
  - Prevailing wind direction (both “average” direction and “strongest” direction) and temporal variation.
  - Sites of Special Scientific Interest (SSSIs), other sensitive environmental designated sites and heritage features (on-site or adjacent to the site).
  - Significant manmade features.
- **Contaminant Definition**
  - Location of potential and actual sources of contamination relative to boundaries on the site.
  - Delineation of primary and secondary sources of contamination.
  - Description of contaminant form (solid, liquid, gas).
  - The type of contamination, e.g. fission products, plutonium isotopes, tritium, uranium, hydrocarbons, solvents, lead, mercury, etc.
  - The potential hazard caused by the contamination (e.g. radioactivity, carcinogenic, phytotoxic, etc.).
  - The cause of contamination and its origin.
  - Background/baseline water quality.
  - The length of time since the release of the contamination (and the period over which the contaminant was released into the environment).
  - The potential mobility of the contaminants and the factors which attenuate the migration of the contaminants.
  - The potential lateral and vertical extent of the contamination and the potential volume of ground and groundwater impacted.

- The potential concentration of the contamination and how this varies in space and time.
- Uncertainties in the above.

- **Receptors**

  Identification of the receptors which could be potentially impacted by the contamination (on-site and off-site) and should be considered within the relevant legal or policy context. These receptors include:
  - On-site workers (general and contaminated area);
  - Off-site workers adjacent to the site;
  - Visitors to the site;
  - Off-site members of the public;
  - Controlled waters/water environment (including surface water and groundwater);
  - Potable abstractions;
  - Protected species and designated sites of nature conservation;
  - Crops, livestock, wild animals which are subject to shooting or fishing rights;
  - Property on-site and on nearby sites (including buildings, underground services/structures, and historical/archaeological important features);
  - Any compliance boundary(-ies) relevant to regulatory regime(s).

- **Pathways**
  - The pathways and mechanisms by which contamination might reach and thereby impact a receptor (including direct irradiation/"shine" for some types of radioactivity).

  Examples of Pathways are given in the "Potential Pathways" section of Table 4.

- **Source-pathway-receptor linkages**
  - Plausible source-pathway-receptor linkages (e.g. in tabular or graphical format).
  - Include monitoring results showing the existence or absence of a pathway.
  - Current mitigation arrangements to reduce the potential impacts of the contamination to human health and the environment.
  - Depending on the scope and purpose of the assessment, consideration may need to be given to possible changes in linkages under future site conditions (e.g. after reaching a key stage in decommissioning of the site).
- **Uncertainty**
  - Gaps in understanding that can be addressed by further investigation.
  - Natural variation in properties that can never be fully characterised.

2.4 Details of the Qualitative Risk Assessment Method

The Q_LRA will involve a number of activities, grouped below under the steps in the "Greenleaves II" framework (with the equivalent "Greenleaves III" terminology in brackets). Further detail on each step is given in Table 4, which, together with the linked Tables 5-7 constitutes the basis of the Q_LRA methodology in this document.

As SNIFFER (2007) advises, the starting point is establishing the legislative context for assessing the severity of consequence. The context will both determine constraints and the level of risk triggering action.

Hazard Identification (Identify Hazards)

(i) identifying APCs in terms of: location, buildings, type of contaminants, form of the contaminants, origin of contaminants, properties of the contaminants, description of occurrence, likely concentration of the contaminants and the magnitude of the total mass or activity of each contaminant. (In situations where contamination is known to originate from another APC it should be ensured that the APC in question is part of the Q_LRA).

Hazard Assessment (Assess Consequences)

(ii) the identification of receptors which may be exposed to the contaminants and what that exposure would entail (what would be the response of the receptor to exposure to different levels of contaminants);

(iii) the identification of potential pathways by which the receptors may be impacted by the contaminants and the exposure mechanisms;

(iv) the identification of any means by which the potential impacts from the contamination are currently mitigated;

(v) an assessment, using the descriptors in Table 5, of the potential severity of the consequence(s) of the impact (separately for the short term and long term; terms which are described at the end of this section).

Risk Estimation (Determine Probabilities of Consequences)

(vi) an estimation, using the descriptors in Table 6, of the likelihood of the consequence occurring (separately for the short term and long term) and hence a description of the "Significance of the Risk" using the descriptors in Table 7.

Risk Evaluation (Characterise Risk)

(vii) identification of key sources of uncertainty, including assumptions, which could affect the outcome of the risk estimation, and description of the confidence in the risk assessment (using the "low"/"medium"/"high" confidence descriptors defined in the relevant part of Table 4);

(viii) given the legislative or other context, establish the level of risk presented by the contamination that would trigger further action including remedial action (taking into account discussion in Section 3);

(ix) evaluate the acceptability of the estimated risk in both the short term and the long term (taking into account discussion in Section 3).

ALARP Considerations and Controls

(x) for land impacted by radioactive contaminants on nuclear licensed sites, consider whether the risks are ALARP and evaluate the adequacy of existing controls. Consider whether additional proportionate controls should be implemented to reduce risks to be ALARP (If so, these controls should be implemented).

Re-assessment of Q_LRA

(xi) state criteria for review/re-assessment of the Q_LRA, e.g. in terms of revisiting after implementation of additional controls or other future site land quality management milestones, after a future change in site conditions, or as a specified review date.

In application, it is advised that the information required for the Q_LRA (as well as the output of Q_LRA) is captured in a spreadsheet, using the suggested column headings set out in Table 4. All the information can be collated in either a single large table, or in sub-tables within the spreadsheet.

Table 4 presents descriptions of the terms used in the column headings of the risk assessment table(s), including definitions of descriptors of confidence in the risk assessment.

The column headings include both inputs and outputs of the risk assessment.

Tables 5, 6, and 7 give definitions of descriptors to be used in the main steps of the risk assessment process, namely hazard assessment (severity) and risk estimation (likelihood and significance), as explained in Section 2.5.

Assessment of risks in both the short term and long term is recommended, to distinguish between:

(i) potential pollutant linkages that are unlikely to be significant now or in the near future, assuming that the ground is not disturbed;
(ii) potential pollutant linkages that are or could be present and significant now, and will continue to be in the future (unless remedial intervention takes place); and
(iii) potential pollutant linkages that are unlikely to be significant now, but which could become so in the long term, in the absence of any managed change in site conditions/use.

Examples of the last case (iii) could be:

- a potential source of contamination becoming an actual source; e.g. due to degradation of the integrity of a single-skin tank;
- a pollutant linkage becoming connected; e.g. a slowly moving groundwater plume approaching the site boundary or off-site receptor;
- the likelihood of exposure occurring increasing with time; e.g. due to reduced certainty in off-site receptor behaviour or off-site land use (outside the control of the site owner/operator) in the long term.

Note that if the assessor wishes to assess risks under potential/planned managed changes to site conditions/use, the “short term” would be at the outset of the new site conditions, and the “long term” would relate to the continuation of the new site conditions in the absence of any further managed change. In other words, a clear separation is needed between an assessment of risks for current site conditions/use and any assessment(s) for potential/planned future site conditions/use(s).

What is meant by “short term” and “long term” should be defined by the risk assessor at the outset, appropriate to the context of the assessment. If appropriate, the risk-mitigating controls assumed to operate in each time-frame should be described. For a typical nuclear site where the contamination being assessed originated some decades ago, “short term” will typically be of the order of 5 years (or less if the ground is to be disturbed or other changes in site conditions/use are planned) while “long term” will typically be some decades.

It is recommended that what is meant by “short term” and “long term” should be inserted into the relevant column headings of the risk assessment table(s) (see Table 4).

Table 4: Qualitative Risk Assessment Methodology – Descriptions of Suggested Table Headings

Header in Table	Description
Hazard Identification	
APC Reference	Reference number for the area of potential concern (APC) e.g. 1, 2, 3
Pollutant Linkage Reference	A code for each set of pollutant linkages associated with the APC. For example, 3-R-OnW could represent: • 3 – APC reference number; • R – Potential contaminant type (e.g. radionuclides); • OnW – Receptor code (e.g. on-site workers). It is expected that pollutant linkages between the same contaminant type and the same receptor via different pathways will be assessed together. [Note that coding of APCs, contaminants, pathways, receptors and pollutant linkages can be customised according to the needs of the site.]
Risk Assessment Area	Description of the "risk assessment area" e.g. on-site, outside the security fence, Zone B, etc.
APC Title	Description of the building, facility or area of land, such as: • Area 1001; • Open land west of Building 456; • Building 456 Oil Storage Tank.
Description of Occurrence	Description of the potential land contamination, such as: • Leak from above-ground oil storage tank; contamination at surface; • Contamination beneath Building A foundation slab; • Leak from low active drain, contamination beneath building B; • Leak from underground petrol storage tanks.
Potential Contaminants	Identities of potential contaminants, such as: • R = Radionuclides (^{60}Co, ^{137}Cs, ^{235}U, etc.); • H = General hydrocarbons (fuels, oils, etc.); • M = Heavy metals; • C = Chlorinated hydrocarbon solvents; • P = Poly-chlorinated biphenyls (PCBs); • A = Asbestos.
Potential Quantity of Contaminants	Original volume or mass of contaminants, such as: • Of order 10 MBq (mainly Cs-137) in about 1000 m^3 of low level active liquor; • About 1-5 m^3 of waste solvent, of which most thought to be TCE; • Of order 100 MBq uranics in about 20 tonnes of rubble.
Form of the Contaminants	Original form of contaminant(s), e.g. • Solid; • Suspension (e.g. slurry/sludge); • Dissolved in water; • Non-aqueous liquid; • Gas. [This would usually be the form of contaminant when released into/onto the ground. Be clear if it relates to a secondary source within contaminated soil.]
Properties of the Contaminants	Properties of the contaminants in the environment, such as • aqueous solubility of contaminant; • solubility of contaminant in other solvents likely to be present; • sorptivity of contaminant; • pH of water; • composition of soil including pH and organic content.

Header in Table	Description
Likely Concentrations of Contaminants (range and maximum) in Soil and/or Groundwater	Calculated from sample analysis or estimated from information concerning source. Typically reported in Bq kg^{-1} for radionuclides; mg kg^{-1} or $\mu g\ l^{-1}$ for chemicals in soil or water respectively.
Hazard Assessment	
Receptors (potentially impacted from land contamination)	Description of the receptors which could be potentially impacted by the contamination (on-site and off-site) which should be considered within the relevant legal or policy context. These receptors (from Table 3) may include: • On-site workers (general and contaminated area); • Off-site workers adjacent to the site; • Visitors to the site; • Off-site members of the public; • Controlled waters/water environment (including surface water and groundwater); • Potable abstractions • Protected species and designated sites of nature conservation; • Property on-site and on nearby sites (including buildings, underground services/structures, and historical/archaeological important features); • Crops, livestock, wild animals which are subject to shooting or fishing rights; • Any compliance boundary(-ies) relevant to regulatory regime(s).
Potential Pathways	Pathways between the contaminants and receptors. To include consideration of the transport mechanism and the exposure pathway (i.e. how does/might the contamination reach the receptor, and how might the receptor be exposed to the contamination?). *Example 1* *Transport mechanism* • Transport of contaminants in water by infiltration of rain, percolation through the unsaturated zone to groundwater. Groundwater then used for irrigating crops. *Exposure pathway* • Ingestion by humans through consumption of contaminated drinking water; • Ingestion by humans through consumption of contaminated food (vegetables, fruit, milk, meat, fish, etc.). *Example 2* *Transport mechanism* • Contaminated dust blown to areas on-site and off-site. *Exposure pathway;* • Inhalation by on-site workers by breathing dust; • Inhalation and ingestion by grazing animals off-site and subsequent ingestion of meat products by off-site humans. Potential exposure pathways can be coded, e.g.: • Irr – Direct irradiation (“shine”); • InV – Inhalation of vapour; • InD – Inhalation of dust; • Ing – Ingestion; • DEx – Dermal Exposure; • SWF – Flow overland or in engineered surface water drain (e.g. to surface water receptor); • USF – Unsaturated zone flow (e.g. to groundwater); • GWF – Flow in groundwater (e.g. towards potable abstraction). [NB the above example coding is not prescriptive and is likely to need tailoring to site conditions (e.g. if the pathway involves more than one

Header in Table	Description
	processes "in series", such as flow in groundwater and abstraction for irrigation).]
Summary of CSM	Description of the "source-pathway-receptor" linkages (actual and potential). This should provide site-specific detail on how the source originated and how the types of pathways and receptors are linked.
Legislative Context	Identification of the regulatory regime applicable to the contaminant(s) and receptor. [This column may be omitted if the legislative context is readily linked to the types of contaminant and has been clearly documented at the pre-assessment context-setting stage.]
Current Mitigation of Pollutant Linkages	The means by which the impacts from the contamination are mitigated, by Receptor Exclusion, Pathway Interruption or Source Containment, such as: • Shielding of radiation by overlying clean soil or slab; • Natural sorption properties of the soil; • Natural attenuation processes in the groundwater; • Restrictions on access (e.g. signage, fencing/barriers, other security systems, etc); • Temporary or longer-term containment structures (e.g. tenting); • Hydrological barriers, whether purpose-designed or not (e.g. limiting infiltration); • Monitoring with mitigation action plan in place (noting that monitoring *per se* is not mitigation); • Combination of the above; • None.
Potential Severity of Consequence if Exposure Occurs in the Short Term[11]	The severity of the consequence of the pollutant linkage being fully realised in the short term (i.e. less than ~5 years, or shorter if appropriate – see Section 2.4), taking account of any mitigation. The descriptors of "severity of consequence" associated with particular receptor types are set out in **Table 5**. The classification is intended to assess land in an undisturbed condition.
Reasoning Behind Short Term Severity of Consequence	Summary of the rationale for the selection of the descriptor for "Potential Severity of Consequence" in the short term (Table 5). See Section 2.5.1 for a discussion of how to identify the appropriate Severity descriptor.
Risk Estimation and Risk Evaluation	
Likelihood of Consequence Occurring in the Short Term	The likelihood of a consequence occurring due to exposure to contaminant in the short term. Definitions of the descriptors of "Likelihood" are given in **Table 6**.

[11] It is recommended that what is meant by "short term" and "long term" should be inserted into this and other relevant column headings of the risk assessment table(s). See Section 2.4 for discussion of what is meant by "short term" and "long-term".

Header in Table	Description
Reasoning Behind Short Term Likelihood of Consequence	Summary of the rationale for the selection of the descriptor for "Likelihood of Consequence Occurring" in the short term (Table 6). The reasoning should demonstrate that the "Potential Severity of Consequence" and the "Likelihood of Consequence Occurring" are self-consistent for the exposure scenario. See Section 2.5.2 for discussion of how to achieve this. [Avoid falling into the potential trap of thinking that "likelihood" is about whether any consequence will occur, rather than the likelihood of the assessed severity of consequence occurring. If the likelihood of the initially chosen consequence is assessed as zero, then re-visit the choice of consequence.]
Significance of Risk (Short Term)	As defined using **Table 7**.
Changes in Assessment in the Long Term	Summary of reasons for the selection of any different descriptors for "Potential Severity of Consequence" (Table 5) or "Likelihood of Consequence Occurring" (Table 6) for the long term (compared to the short term).
Significance of Risk (Long Term)	As defined using Table 7.
Descriptor of **Confidence in the Assessed "Significance of Risk"** (Short and Long Term)	Taking into account the information available, the confidence in the assessment should be rated using the following definitions: • **High** (unlikely to change if new information becomes available, and if changed would be towards lower significance); • **Medium** (could well change by one level of significance if new information becomes available, most likely towards lower significance); or • **Low** (could well change by more than one level of significance if new information becomes available, or as likely to change to higher significance as lower). Record any variance in confidence between short and long term.
Reasoning Behind Confidence in the Assessed "Significance of Risk" (Short and Long Term)	Qualitative statement of the rationale for the stated confidence descriptor, stating if there is a lot of information available to support a "High" rating, but also highlighting key areas of uncertainty relevant to the specific APC and pollutant linkages, such as: • Uncertain existence, magnitude or composition of source; • Uncertain existence or effectiveness of pathway (e.g. uncertain hydrogeology); • Lack of quantitative site characterisation information; • Uncertain existence or characteristics of receptor; • Identified gaps in critical information/data; • Uncertainty in changes to the site conditions in the long term. [It is important to make this entry as specific as possible, as it is likely to provide useful information for specifying further information-gathering work.]
ALARP Considerations (for land impacted by radioactive contamination)	
ALARP and existing controls	Comment on the adequacy of existing controls and whether these give confidence that the risks from the land impacted by radioactive contaminants are ALARP.
Further proportionate control measures to ensure risks are ALARP	Identify any further proportionate, implementable control measures that would ensure that risks from the land impacted by radioactive contaminants are ALARP. If options appraisal is needed to identify which measures should be implemented, then state this, rather than prematurely attempt to rank options in the context of the Q_LRA.

Header in Table	Description
Criteria for Review/Re-assessment of Q_LRA	
Q_LRA Review/Re-assessment Criteria	State criteria for review/re-assessment of the Q_LRA, e.g. in terms of revisiting after implementation of additional controls or other future site land quality management milestones, or as a specified review date. Milestones could be based on any potential planned development of the land which may involve changing its use (e.g. affecting receptors) or disturbing the contamination from its current state, or could be planned entry to a quiescent phase of the site's life-cycle. Otherwise, review dates (not based on milestones) may be appropriate, taking into account any assessed changes of Risk Significance with time (comparing Short and Long terms).

2.5 Assessment of Significance of Risk (Risk Estimation and Evaluation)

To assess the "Significance of Risk" to particular receptors from particular pollutant linkages, reference must be made to Tables 5, 6 and 7. "Significance of Risk" (Table 7) is estimated using a combination of "Potential Severity of Consequence" (Table 5) and "Likelihood of Consequence Occurring" (Table 6).

It should be noted that "Severity" and "Likelihood" interact in assessing risk. The consistent use of the terminology provided here is important to understanding the output of the assessment. It is strongly recommended that the definitions presented in Tables 5-7 are appended to reports making use of this methodology, so that readers of such reports are aware of the methodology and definitions used.

2.5.1 Potential Severity of Consequence

The receptors considered within Table 5 are:

- on-site workers;
- members of the public (including site visitors);
- property (including buildings, crops and livestock);
- sensitive ecosystems and protected habitats;
- the water environment (which includes surface waters, groundwater, coastal waters and potable abstractions; and
- any relevant compliance boundary(-ies).

A measure of consistency between receptors has been attempted by defining "Severe" to mean a consequence that could not unreasonably be expected to lead to formal regulatory action (e.g. Part 2A determination) or other legal action by a regulator or affected party. As mentioned previously, it is important to recognise that no claim is being made that there is objective parity of severity descriptors between receptors. For example, no claim is made that a "Severe" consequence to property is in some way comparable to a "Severe" radiation dose to a member of the public.

The Severity descriptors in Table 5 have been derived by building on two existing guidance documents that themselves build upon the DETR "Greenleaves II" guidance and the CIRIA (2001) contaminated land risk assessment guidance, and taking into account Part 2A Statutory Guidance (Defra, 2006; Scottish Executive, 2006). The existing guidance is provided by the NHBC/EA/CIEH (2008) in Annex 4 of R&D66:2008 and in Annex D of the Defence Estates (2007) Land Quality Assessment Management Guide (here referred to as DE PG01/07). These existing guides address most types of receptor listed above (without explicitly separating on-site workers from members of the public) but do not consider radiological aspects or risks to any relevant compliance boundaries. Appendix 2 of this document provides a comparison between severity descriptors for those receptors covered by the previous guidance, which shows that much of the terminology used here (for those receptors) is largely broadly consistent with the earlier guidance, which has either been endorsed by an appropriate regulator (EA) or has been widely used by the Government agency (MoD) with the largest holdings of land potentially affected by contamination in the UK.

2.5.1.1 Severity of Consequence Descriptors for Non-Radioactive Contamination

In the case of non-radiological risks to human health, the approach is to relate "severity" definitions to the EPA90 Part 2A Statutory Guidance criteria for "significant harm", but not as directly as in CIRIA (2001) or DE PG01/07. The approach here is more like that in

R&D66:2008 where severity criteria are based on potential levels of contamination ("concentrations" in R&D66:2008) in exposed media. The wordings in Table 5 are not the same as in R&D66:2008 (see Appendix 2) for reasons explained below. This approach means that the risk assessor needs to know the levels of contamination that would generally be considered sufficient to indicate "significant possibility of significant harm" (were exposure to occur) but does not need to have detailed knowledge of the health consequences of exposure to different levels of contamination. However, to make this approach work, the risk assessor must have sufficient knowledge of relevant generic work (e.g. a basic understanding of the basis and applicability of available GACs (Generic Assessment Criteria) for soil).

The definitions in R&D66:2008 rely on "concentrations" of contaminants, whereas for Q_LRA, the risk assessor may not have any contaminant concentration data but may have in mind visual or olfactory observations indicative of more qualitative "levels" of contamination. The definitions in Table 5 are intended to allow such qualitative judgements to be taken into account.

A further problem with the severity definitions for human health in R&D66:2008 is that they incorporate terms such as "likely", "could" and "unlikely", which are not precisely defined, and may in fact have to have different meanings from those used when assessing the likelihood/probability of the consequence (exposure) occurring (Table 6).

In view of the above, the descriptors of severity of consequence for non-radiological impact on human health in this guidance (Table 5) are expressed in terms of exposure of people to different "levels" of contamination, and these "levels" are defined in terms of the "acceptability" of the contamination in the (potentially hypothetical) case that exposure of people occurs (i.e. without taking account of the likelihood/probability of the consequence (exposure) occurring). These definitions are linked to criteria in the Part 2A regulatory regime, and are deliberately imprecisely worded to allow the risk assessor to use their judgement as to the severity of the potential level of contamination.

Some of the descriptors of severity for human health in Table 5 state that if quantitative data were available, comparison of such data with GACs or SSACs (Site Specific Assessment Criteria) "could" be used to inform the assessment of severity. However, as this is a qualitative risk assessment methodology, this supplementary aspect of the definitions should not be over-emphasised. See also Section 2.5.1.4.

It is important to bear in mind the context of using the phrase "significant possibility of significant harm" (SPOSH) in the definition of "Severe" in Table 5. Using the term "Severe" in the consequence assessment part of a risk assessment does not of itself mean that there is SPOSH, because at this stage in the risk assessment the likelihood/probability of the consequence occurring has not been incorporated. See also Section 2.5.3.

For other receptors potentially affected by non-radioactive contamination (other than the water environment), the descriptors of severity of consequence follow the same rationale as for human health.

In the case of the water environment (including controlled waters and potable abstractions), the severity descriptors in R&D66:2008 were based on the Environment Agency's then definitions of categories of "pollution incident". These categories have since been superseded by those in the "Common Incident Classification Scheme" (CICS) (Environment Agency, 2011). However, these "incident" definitions are not readily applicable to potential pollution of the water environment arising from long-standing land contamination. Moreover, the highest category of CICS incident (Category 1) is considered to be too extreme to be the basis of a descriptor of "Severe" consequence commensurate with the descriptors for other receptors. Furthermore, a determination criterion of "significant pollution of the water environment" exists

for Part 2A of EPA90 in Scotland (supported by guidance within SEPA, 2010) and its equivalent ("significant pollution of controlled waters") is expected to be introduced by the revised statutory guidance for Part 2A of EPA90 in England and Wales due out in 2012[12]. The statutory and regulatory guidance typically uses the term "significant" to describe the magnitude of effect on the water environment at which regulatory action of some kind might be expected, and thus should be considered a "severe" consequence in the context of the present document. The descriptors of potential severity of consequence for the water environment in Table 5 are not intended to be over-prescriptive but to give the risk assessor some "benchmarks" when considering potential severity of consequence for water environment receptors. These "benchmarks" include use of EA CICS definitions for surface waters and potable abstractions, and Appendix 3 provides details of these. See also Section 2.5.1.4 for consideration of quantitative aspects of these definitions.

2.5.1.2 Severity of Consequence Descriptors for Radioactive Contamination

In a Q_LRA, actual estimates of radiological dose are unlikely to be available. In assessing the potential severity of consequence, the onus is on the risk assessor to judge the order of magnitude of dose that could result, if exposure were to occur.

Note that these severity descriptors are primarily in terms of radiation dose. Comparison of contaminant concentrations in exposed soils with generic radionuclide assessment criteria (GRAC) is one (but not the only) potential means of demonstrating the severity level (if relevant data are available).

The severity descriptors for radiological dose are new and may not be agreed with by all regulators. However, they are based on the general approach of defining "Severe" to mean a consequence that could not unreasonably be expected to lead to formal regulatory action (e.g. Part 2A determination) or other legal action by a regulator or affected party. Regardless of assessed severity of consequence and likelihood (and hence significance), users of this guidance should always take account of the principles of keeping radiological risks ALARP/ALARA (optimised).

2.5.1.3 Severity of Consequence Relevant to Compliance Boundaries

The severity of the potential consequence of contamination crossing a compliance boundary (if one can be defined)[13] requires a different approach from other receptors, since the consequence may be a business/reputational issue for the site operator rather than actual impact on a receptor. It is included to reflect the importance attached to regulatory compliance, and to acknowledge that this may affect decision-making. The action that might be taken, should a non-compliance of this type actually occur, would be a matter for the regulator. The risk assessor may wish to develop severity descriptors appropriate to the context of the specific assessment.

[12] Note that the determination criteria in Part 2A of EPA90 also include "significant possibility" of (significant) pollution of the water environment (controlled waters). However, for water environment receptors, "significant possibility".relates to the likelihood of the pollutant linkage being operative (now or in future) and therefore does not provide a valid input to a descriptor of severity of consequence. This is unlike the situation for other receptors, where "significant possibility of significant harm" (SPOSH) incorporates the likelihood that an exposure (if it occurs) would result in significant harm, as well as the likelihood of the exposure.

[13] Note that "compliance boundaries" should not be confused with "compliance points" that may be defined for the purposes of assessment of pollutant inputs to groundwater from land contamination (e.g. in SEPA, 2010).

2.5.1.4 Quantitative Aspects of Severity of Consequence Descriptors

The descriptors of severity of consequence for some receptors (e.g. radiological doses to humans; non-radiological risks to humans) include some quantitative aspects. This is for the following reasons:

- Inclusion of quantitative aspects should lead to a greater consistency of use of the severity descriptors by different risk assessors.
- For receptors where quantitative criteria are set in regulations (e.g. radiological dose limits), such criteria need to be reflected in the definition of "severe" consequence.
- For risks to human health from non-radioactive contamination, it allows generic knowledge that underpins the development of GACs to be "taken as read" (analogous to using the concept of radiological dose for exposure to radioactive contamination).

The use of quantitative screening criteria (e.g. GACs or GRACs) in some severity definitions does not mean that Q_LRA should replace a full Tier 2 Generic Quantitative Risk Assessment (GQRA). A full GQRA should be based on representative data from investigations designed with GQRA in mind. Also, the inclusion of quantitative aspects in the severity descriptors does not mean that representative quantitative data are required in order to undertake Q_LRA. Indeed, such data are unlikely to be available for (preliminary) Tier 1 Q_LRA. However, it does mean that Q_LRA should always be undertaken by or under the supervision of a professional who is sufficiently experienced in quantitative risk assessment that the quantitative aspects of the severity descriptors are properly understood.

It is also important to ensure that appropriate quantitative screening criteria are used. For example, in the case of the water environment, care is needed to ensure that the choice of GAC is consistent with other elements of the severity definition (e.g. avoiding using drinking water standard values as GAC for groundwater that is not a credible resource).

It is important to note that in many cases, actual contaminant concentration data may be lacking. In such cases, the risk assessor should use a severity description corresponding to the worst credible level and extent of contamination, given the available information. See also Section 2.5.3.

2.5.2 Likelihood of Consequence Occurring

The descriptors used for assessing likelihood of a consequence occurring to a receptor via a particular pollutant linkage are shown in Table 6. These definitions are more quantitative than are found in R&D66:2008 (NHBC/EA/CIEH, 2008) but (as shown in Appendix 2 to this document), they are consistent with DE PG01/07 and also broadly consistent with definitions used in the highly scrutinised field of climate change (IPCC, 2007).

The use of quantitative definitions of descriptors of probability/likelihood of consequence occurring is primarily intended to lead to greater consistency of use of these descriptors by different risk assessors.

Likelihood of a consequence occurring is expressed in terms of:

- Very Likely / Certain;
- Likely;
- Unlikely;
- Very Unlikely; or
- Extremely Unlikely.

Note that the descriptor "Likely" has been defined in Table 6 to encompass "as likely as not" as defined in DE PG01/07.

The “Extremely Unlikely” descriptor has been added to take account of the tendency in the nuclear industry to consider “very low probability, high consequence” events.

The likelihood/probability of occurrence is not a per annum probability but a more qualitative probability relating to the period under consideration. Typically, for a nuclear site, this will be of the order of 5 years for the short term and of the order of a few decades for the long term. It is essential to state the period over which the likelihood of consequence occurring is being assessed.

As already discussed in relation to the severity descriptors, Q_LRA should always be undertaken by experienced land quality risk assessment professionals with good access to site-specific knowledge, who can make well-informed judgements concerning the likelihood of specific potential pollutant linkages being realised on the time-scales being assessed. This is particularly the case for preliminary Q_LRA for APCs or pathways for which little information is available. This in turn leads to a need for experience in assessing the uncertainties and level of confidence in the risk assessment for any given APC and related potential pollutant linkages.

2.5.3 Consistent Assessment of Severity and Likelihood of Consequence

Severity of consequence and likelihood of consequence occurring should not be assessed in isolation from each other. For a given potential pollutant linkage, the risk assessor typically has to choose between a “worst case” consequence (usually of relatively low likelihood) and a more credible consequence (with correspondingly higher likelihood). The outcome in terms of significance of the risk should be about the same, but it is important to be clear about why a particular severity of consequence has been chosen.

As a general guide, if there is very little site-specific information about a potential pollutant linkage, the assessor should consider the “worst credible consequence” and then use his/her experience to assess the likelihood of that consequence occurring (taking into account any mitigation is that are already in place). One way to think of this is whether it is credible that a “severe” consequence could occur.

On the other hand, if there is reasonably good information available about the source (APC) and relevant pathway(s), the assessor should consider the “most credible consequence”, and assess the likelihood as being either “certain” (if there is no doubt that the pollutant linkage is operative) or some lesser likelihood (if the pollutant linkage might be operative or become operative over the timescale being assessed).

There is a particular difficulty in dealing with potential pollutant linkages that verge on the incredible; e.g. because the source is very small, the pathway(s) most likely do not exist, or the receptor is hypothetical or non-sensitive. The assessor should in some cases judge that there is no potential pollutant linkage to assess, and this can be reflected using the “no linkage” option indicated in Table 6. Alternatively he/she may judge that the worst credible consequence is both “negligible” and “very/extremely unlikely”. However, care is needed to avoid “double counting” relatively low likelihood of relatively severe consequences in both the assessments of severity and likelihood. In particular, care is needed where there is only a small source and/or no sensitive receptor, such that a severe consequence is not credible, but a pollutant linkage is known or likely to be operative. It is potentially tempting to report a relatively low severity consequence but then also state that it is (very/extremely) unlikely to occur, even though a pollutant linkage is operative. The proper way to convey this type of situation is to report relatively highly likelihood of a (very) low severity consequence.

For non-radiological risks to human health (and other receptors to which the concept of “significant harm” applies) when assessing the likelihood of a specific consequence occurring,

it is the likelihood of the potential pollutant linkage being operative (e.g. people being exposed to the relevant level of contamination) that is being assessed, not the likelihood that significant harm will occur.

2.5.4 Significance of Risk

Using the descriptors for “Potential Severity of Consequence” and “Likelihood of Consequence Occurring”, the “Significance of the Risk” to a receptor from a particular pollutant linkage can be established using the matrix shown in Table 7. The “Significance of the Risk” terms thus defined are:

- Very High;
- High;
- Medium;
- Low;
- Very Low;
- Trivial; or
- None.

As shown in Appendix 2, Table 7 is very similar to the schemes in CIRIA (2001) and in R&D66:2008 (NHBC/EA/CIEH, 2008), but eliminating ambiguous terms such as “low/moderate”.

Table 5 Descriptors for "Potential Severity of Consequence"[14]

	Negligible	Mild	Moderate	Severe
Radiation dose to public	Less than of order 0.01 mSv y^{-1}, were exposure to occur. This level corresponds to a risk of death of 10^{-6} y^{-1}, as defined by the Radioactive Substances (Basic Safety Standards Direction) (England and Wales) Direction 2000 and the Radioactive Substances (Basic Safety Standards Direction) (Scotland) Direction 2000, and is not subject to any regulatory controls. May be demonstrated by presence of exposed soils with no or only localised exceedence of GRAC for scenarios applicable to site use for 0.01 mSv y^{-1}.	Of order 0.01 – 0.1 mSv y^{-1}, were exposure to occur. May be demonstrated by presence of exposed soils with no or only localised exceedence of GRAC for scenarios applicable to site use for 0.1 mSv y^{-1}.	Of order 0.1 - 1 mSv y^{-1}, were exposure to occur. The upper level corresponds to the legal limit for effective dose in a calendar year for any member of the public from sources of ionising radiation originating from a nuclear licensed site. This range is of a similar order to the dose constraint of 0.3 mSv y^{-1} in EA Briefing Note 3 (2006) and recommended by HPA (NRPB, 1998) for development of land under Planning legislation. May be demonstrated by presence of exposed soils with no or only localised exceedence of GRAC for scenarios applicable to site use for 1 mSv y^{-1}.	Of order > 1 mSv y^{-1}, were exposure to occur. This level of dose exceeds the legal limit for effective dose in a calendar year for members of the public from sources of ionising radiation originating from a nuclear licensed site. This is of a similar order to the 3 mSv y^{-1} criterion for determination of "radioactive contaminated land" not on a nuclear licensed site under EPA90 Part 2A. May be demonstrated using the EPA90 Part 2A criteria for "radioactive contaminated land" or by presence of exposed soils with extensive exceedence of GRAC for scenarios applicable to site use for 1 mSv y^{-1}.
Radiation dose to on-site "general employees"	Of order 0.01 – 0.1 mSv y^{-1}, were exposure to occur. The upper level corresponds to the Basic Safety Objective for "other employees" working on a nuclear licensed site – Target 1 in HSE SAPs.	Of order 0.1 - 2 mSv y^{-1}, were exposure to occur. The upper level corresponds to the Basic Safety Level target for "other employees" working on a nuclear licensed site – Target 1 in HSE SAPs.	Of order 2 - 10 mSv y^{-1}, were exposure to occur. The upper level corresponds to the Basic Safety Level target for average effective dose in a calendar year to defined groups of "employees working with ionising radiation" on a nuclear licensed site – Target 2 in HSE SAPs.	Of order > 10 mSv y^{-1}, were exposure to occur. This exceeds the Basic Safety Level target for average effective dose in a calendar year to defined groups of "employees working with ionising radiation" on a nuclear licensed site – Target 2 in HSE SAPs.
Radiation dose to on-site "employees working with ionising radiation"	Of order 0.1 – 1 mSv y^{-1}, were exposure to occur. The upper level corresponds to the Basic Safety Objective for "employees working with ionising radiation" on a nuclear licensed site – Target 1 in HSE SAPs.	Of order 1 - 10 mSv y^{-1}, were exposure to occur. The upper level corresponds to the Basic Safety Level target for average effective dose in a calendar year to defined groups of "employees working with ionising radiation" on a nuclear licensed site – Target 2 in HSE SAPs.	Of order 10 -20 mSv y^{-1} were exposure to occur The upper level corresponds to the Basic Safety Level Legal Limit for average effective dose in a calendar year to "employees working with ionising radiation" on a nuclear licensed site – Target 2 in HSE SAPs.	Of order > 20 mSv y^{-1}, were exposure to occur. This level exceeds the Basic Safety Level Legal Limit for average effective dose in a calendar year to "employees working with ionising radiation" on a nuclear licensed site – Target 2 in HSE SAPs.

[14] The reader is strongly recommended to read Section 2.5.1 to ensure that this table is properly understood. See also Section 2.5 for a discussion of the rationale for inclusion of qualitative aspects within these definitions of qualitative descriptors for severity.

	Negligible	Mild	Moderate	Severe
Harm to humans (health risks from non-radioactive contamination)	People being exposed to contaminants in soil or other media at levels that represent negligible/minimal risk to human health. No perceptible nuisance. If quantitative data were available, this could be demonstrated by non-exceedance of background/normal levels, or GACs[15] for threshold substances.	People being exposed to contaminants in soil or other media at levels with acceptably low likelihood of leading to "significant harm" to human health as defined for the EPA90, Part 2A[16] ["Acceptably low likelihood" of significant harm being in the situation of people actually being exposed]. Or perceptible nuisance (e.g. VOC odour). If quantitative data were available, this could be compatible with only slight or localised exceedances of background levels or GACs.	People being exposed to contaminants in soil or other media at levels giving rise to reasonable concern about the possibility of "significant harm" to human health as defined for the EPA90, Part 2A, but not indicative of SPOSH[17]. ["Reasonable concern" about the possibility of significant harm being in the situation of people actually being exposed]. If quantitative data were available, this could be indicated by widespread substantial exceedances of GACs.	People being exposed to contaminants in soil or other media at levels that could reasonably be construed as indicative of SPOSH (significant possibility of significant harm) to human health as defined for the EPA90, Part 2A. [SPOSH being in the situation of people actually being exposed]. If quantitative data were available, this could be indicated by widespread gross exceedances of GACs.
Harm to flora and fauna	Any ecological system or living organism forming part of such a system being exposed to contaminants in soil or other media at levels that could not lead to "significant harm" to an ecological system as defined for the EPA90, Part 2A[18]	Any ecological system or living organism forming part of such a system being exposed to contaminants in soil or other media at levels with acceptably low likelihood of leading to "significant harm" to an ecological system as defined for the EPA90, Part 2A ["Acceptably low likelihood" of significant harm being in the situation of an ecological system actually being exposed].	Any ecological system or living organism forming part of such a system being exposed to contaminants in soil or other media at levels giving rise to reasonable concern about the possibility of "significant harm" to an ecological system as defined for the EPA90, Part 2A, but not indicative of SPOSH. ["Reasonable concern" about the possibility of significant harm being in the situation of an ecological system actually being exposed].	Any ecological system or living organism forming part of such a system being exposed to contaminants in soil or other media at levels that could reasonably be construed as indicative of SPOSH to an ecological system as defined for the EPA90, Part 2A. [SPOSH being in the situation of an ecological system actually being exposed].

[15] GAC sources include current EA SGVs, LQM/CIEH GACs (Nathanial et al. 2009), EIC/CL:AIRE GACs.
[16] i.e. "Death, disease, serious injury, genetic mutation, birth defects or impairment of reproductive functions" (Defra, 2006).
[17] SPOSH = "significant possibility of significant harm" as defined in Part 2A of the Environmental Protection Act and relevant statutory guidance in England, Scotland and Wales.
[18] i.e. "For any protected location: harm which results in an irreversible adverse change, or in some other substantial adverse change, in the functioning of the ecological system within any substantial part of that location or harm which affects any species of special interest within that location and which endangers the long-term maintenance of the population of that species at that location" (Defra, 2006).

	Negligible	Mild	Moderate	Severe
Harm to property (excluding buildings)	Animals or crops being exposed to contaminants in soil or other media at levels that could not lead to "significant harm" to animals or crops as defined for the EPA90, Part 2A[19]	Animals or crops being exposed to contaminants in soil or other media at levels with acceptably low likelihood of leading to "significant harm" to animals or crops as defined for the EPA90, Part 2A ["Acceptably low likelihood" of significant harm being in the situation of animals or crops actually being exposed].	Animals or crops being exposed to contaminants in soil or other media at levels giving rise to reasonable concern about the possibility of "significant harm" to animals or crops as defined for the EPA90, Part 2A, but not indicative of SPOSH. ["Reasonable concern" about the possibility of significant harm being in the situation of animals or crops actually being exposed].	Animals or crops being exposed to contaminants in soil or other media at levels that could reasonably be construed as indicative of SPOSH to animals or crops as defined for the EPA90, Part 2A. [SPOSH being in the situation of animals or crops actually being exposed].
Harm to buildings	Buildings being exposed to contaminants in soil or other media at levels that could not lead to "significant harm" to buildings as defined for the EPA90, Part 2A[20]	Buildings being exposed to contaminants in soil or other media at levels with acceptably low likelihood of leading to "significant harm" to buildings as defined for the EPA90, Part 2A ["Acceptably low likelihood" of significant harm being in the situation of buildings actually being exposed].	Buildings being exposed to contaminants in soil or other media at levels giving rise to reasonable concern about the possibility of "significant harm" to buildings as defined for the EPA90, Part 2A, but not indicative of SPOSH. ["Reasonable concern" about the possibility of significant harm being in the situation of buildings actually being exposed].	Buildings being exposed to contaminants in soil or other media at levels that could reasonably be construed as indicative of SPOSH to buildings as defined for the EPA90, Part 2A. ["SPOSH" being in the situation of buildings actually being exposed].
Pollution of the water environment, including any potable abstraction points[21,22,23]	"Negligible" pollution is what a regulator would typically regard as a potentially discernible but inconsequential effect, such as: • Contaminants of concern detectable in a water environment receptor at levels indistinguishable from local background levels. • Contaminants of concern detectable in groundwater in	"Mild" pollution is what a regulator would typically regard as a discernible but "minimal" effect, such as: • A borderline Category 3/4 incident affecting surface water, as defined in the EA's CICS. [See Appendix A.3.1]. • Contaminants of concern detectable in groundwater in aquifer strata, but below applicable water	"Moderate" pollution is what a regulator would typically regard as a borderline "minimal"/"significant" effect, such as: • A Category 3 incident affecting surface water, as defined in the EA's CICS. [See Appendix A.3.1]. • Contaminants of concern detectable in groundwater above applicable water quality standards in groundwater in aquifer strata, but	"Severe" pollution is what a regulator would typically term a "significant" or "major" effect on a water environment receptor, such as: • A Category 1 or 2 incident affecting surface water, as defined in the EA's CICS. [See Appendix A.3.1]. • Significant pollution of groundwater, as might be determined under Part 2A of EPA90.[24]

[19] i.e. "For crops, a substantial diminution in yield or other substantial loss in their value resulting from death, disease or other physical damage. For domestic pets, death, serious disease or serious physical damage. For other property in this category, a substantial loss in its value resulting from death, disease or other serious physical damage" (Defra, 2006).
[20] i.e. "Structural failure, substantial damage or substantial interference with any right of occupation" (Defra, 2006).
[21] "Water" includes surface waters (inland freshwaters, coastal waters and relevant territorial waters as defined in Section 104 of the Water Resources Act 1991) and groundwater (all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil).
[22] EA incident categories are from the Common Incident Classification Scheme (CICS) (EA, 2011).
[23] SEPA document "WAT-PS-10-01" is SEPA's Position Statement on "Assigning groundwater assessment criteria for pollutant inputs" (SEPA, 2011).

	Negligible	Mild	Moderate	Severe
	unproductive strata (or non-groundwater body in Scotland), but below applicable water quality standards (e.g. SEPA Resource Protection Values).	quality standards. • A borderline Category 3/4 incident affecting a potable abstraction, as defined in the EA's CICS. [See Appendix A.3.2].	not reaching a relevant compliance point.[24] • A Category 3 incident affecting a potable abstraction, as defined in the EA's CICS. [See Appendix A.3.2].	• A Category 1 or 2 incident affecting a potable abstraction, as defined in the EA's CICS. A Category 2 incident is defined as "Significant effect on a potable abstraction point". [The definition of "significant" in this context is given in Appendix A.3.2]
Contamination crossing a compliance boundary, if not defined as another type of receptor	Although not strictly a measure of risk to people or the environment, it is advised that Q_LRA considers the level (severity) of contamination that could potentially cross a compliance boundary, because this has potential to affect decision-making. The risk assessor may wish to develop context-specific severity descriptors in order to apply this Q_LRA methodology.			

[24] Guidance on compliance points and criteria in Scotland are found in SEPA's document WAT-PS-10-01 (particularly Figure 4), and will be given in Part 5 of EA's document Groundwater Protection: Principles and Practice, due out in 2012.

Table 6 Descriptors for "Likelihood of Consequence Occurring"[25]

Likelihood Descriptor	Probability of Occurrence*
Very Likely / Certain	More than 95%
Likely	45 to 95%
Unlikely	5 to 44%
Very Unlikely	Less than 5%
Extremely Unlikely	Much less than 1%
No pollutant Linkage	Zero

*i.e. probability of occurrence within the time-frame(s) defined for the risk assessment (i.e. "short term" and/or "long term")

Table 7 Descriptors for "Significance of Risk"

	Likelihood of Consequence Occurring	Very Likely / Certain	Likely	Unlikely	Very Unlikely	Extremely Unlikely	No Pollutant Linkage
Potential Consequence	Severe	Very High	Very High	High	Medium	Low	None[#]
	Moderate	High	High	Medium	Low	Very Low	
	Mild	Medium	Medium	Low	Very Low	Trivial	
	Negligible	Low	Very Low	Very Low	Trivial	Trivial	

[#] If there is no pollutant linkage, then the severity of (hypothetical) consequence does not need to be assessed, and the "significance of risk" is "none".

[25] The reader is strongly recommended to read Sections 2.5.2 and 2.5.3 to ensure that this table is properly understood.

3 Risk Evaluation – "Unacceptable" Risks and Follow-up to Qualitative Risk Assessment

The technical risk evaluation part of the Q_LRA methodology presented here generates descriptors of the significance of risks ("Very High" to "Trivial"). However, as stated in "Greenleaves II" (DETR, 2000), *"evaluating the significance of a risk also involves determining the broader implications of the risk problem including social, political and economic considerations. Once these judgments are made about a risk's acceptability, decisions can be taken about how to reduce or manage the risk."* Moreover, in relation to radioactive land contamination on nuclear licensed sites, other technical/regulatory factors must be considered, including any contaminated land safety case, ALARP demonstration, demonstration of compliance with Licence Conditions such as LC34 (concerning containment and detection of leakage/spread of contamination), and demonstration of BAT/BPM.

In relation to regulatory requirements, problem-holders must be able to justify the adequacy of their management of risks associated with land contamination on a case-by-case basis. Therefore, this guidance should not and cannot prescribe what actions should follow identification of risks assessed as having a particular significance based on this Q_LRA methodology.

That said, the purpose of Q_LRA is primarily to identify whether "unacceptable" risks may be present. Therefore it will be helpful to problem-holders to have some guidelines on what might or might not be considered "unacceptable" or "not unacceptable" risks. The Q_LRA process tends to be conservative, and therefore in some cases where an apparently "unacceptable" level of risk arises because of lack of knowledge it may be appropriate to acquire more knowledge before taking further action.

The following broad positions represent a consensus among industry representatives involved in the development of this guidance:

- "Very High" and "High" significance risks are considered to be unacceptable, to the extent that some further steps should be undertaken on an appropriate timescale (which may be "immediate"), whether by implementing additional effective controls to reduce the risk or by gaining additional information to allow conservatisms in the Q_LRA to be reduced. It has to be accepted that the timescales to resolve some "unacceptable" risks are necessarily long.
- "Low", "Very Low" and "Trivial" significance risks are considered to be "not unacceptable", tending to "acceptable" at the "Trivial" level. Other than continued management of the affected land under the conditions to which the Q_LRA relates (and maintaining relevant records), no further steps need be taken, unless the confidence in the Q_LRA is "Low".
- "Medium" significance risks are considered to be "not unacceptable" in the immediate term, but not acceptable over longer timescales. Over longer timescale, such risks should be resolved, either as "unacceptable" risks requiring remedial action, or "not unacceptable" risks where eventually no further action will be taken, for as long as site condition/use remains unchanged.

In interpreting the above, care must be taken to take account of relevant factors. For example, risks assessed to increase in significance in the long term might or might not warrant action in the short term to prevent this from occurring, depending on the reason that the risk would increase in the long term.

In order to provide further, non-prescriptive guidance on these issues, Appendix 4 presents some suggestions by the authors of this document as to how problem-holders might take the risk management process forward following application of this Q_LRA methodology, particularly

for situations where the qualitative risk assessment (rather than other processes such as nuclear safety assessment, ALARP assessment or BAT/BPM assessment) appropriately provides the main input to decision-making at a particular point in the process of managing the contamination. Reference to Appendix 4 may assist in checking that an appropriate assessment has been made; if the suggested response seems excessive or inadequate, then a review to understand the discrepancy may be appropriate (e.g. whether existing mitigating factors/controls have been properly taken into account).

4 Glossary

Term	Definition
ALARA	As Low As Reasonably Achievable
ALARP	As Low As Reasonably Practicable
APC	Areas of Potential Concern
BAT	Best Available Technique
BPM	Best Practicable Means
BSI	British Standards Institute
CICS	Common Incident Classification Scheme [of EA]
CIEH	Chartered Institute of Environmental Health
CIRIA	Construction Industry Research and Information Association
CL:AIRE	Contaminated Land: Application in Real Environments
CLR	Contaminated Land Report
CSM	Conceptual Site Model
Defra	Department for the Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
DoE	Department of the Environment
DRP	Direct Research Portfolio [of NDA]
EA	Environment Agency
EC	European Commission
EIC	Environmental Industries Commission
EPA90 Part 2A	Part 2A of the Environmental Protection Act 1990
EPR10	Environmental Permitting (England and Wales) Regulations 2010 (as amended)
GAC	Generic Assessment Criteria
GQRA	Generic Quantitative Risk Assessment
GRAC	Generic Radionuclide Assessment Criteria
HPA	Health Protection Agency
HSE	Health and Safety Executive
HSWA74	Health and Safety at Work Act 1974
IEH	Institute of Environment and Health
IIG-CL	Inter-Industry Group on Contaminated Land
IPCC	Intergovernmental Panel on Climate Change
IRR99	Ionising Radiations Regulations 1999
LA	Local Authority
LC	Licence Condition
LQM	Land Quality Management Ltd
MoD	Ministry of Defence
NDA	Nuclear Decommissioning Authority
NHBC	National House-Building Council
NIA65	Nuclear Installations Act 1965 (as amended)
NIGLQ	Nuclear Industry Group for Land Quality
NRPB	National Radiological Protection Board [now part of HPA]
ONR	Office for Nuclear Regulation
PCB	Poly-chlorinated Biphenyls
PPC	Pollution, Prevention and Control
PPE	Personal Protective Equipment
Q_LRA	Qualitative Risk Assessment
RSA93	Radioactive Substances Act 1993 (as amended)

Term	Definition
SAPs	Safety Assessment Principles [of ONR]
SEPA	Scottish Environment Protection Agency
SGV	Soil Guideline Values
SNIFFER	Scotland & Northern Ireland Forum for Environmental Research
SPOSH	Significant Possibility of Significant Harm
SSAC	Site Specific Assessment Criteria
SSSI	Site of Special Scientific Interest
TCE	Trichloroethylene
UKAEA	United Kingdom Atomic Energy Authority
VOC	Volatile Organic Compound
WAG	Welsh Assembly Government

5 References

British Standards Institution (2011) BSI BS 10175:2011 Investigation of Potentially Contaminated Sites.

CIRIA (2001) Contaminated land risk assessment: A guide to good practice. CIRIA C552, London.

CIRIA (2009) SAFEGROUNDS: Good Practice Guidance for the Management of Contaminated Land on Nuclear Licensed and Defence Sites Version 2. CIRIA W29, London.

CIRIA (2010) SAFEGROUNDS: The UK regulatory framework for contaminated land on nuclear-licensed sites and defence sites. CIRIA W31, London.

Defence Estates (2007) Practitioner Guide. Contaminated Land Management: Land Quality Assessment (LQA) Management Guide. PG 01/07.

Defra (2006) Environmental Protection Act 1990: Part 2A Contaminated Land. Defra Circular 01/2006, Department for Environment Food and Rural Affairs, London.

Defra (2011) Guidelines for Environmental Risk Assessment and Management – Greenleaves III. PB13670, November 2011.

Department of the Environment (1995) A Guide to Risk Assessment and Risk Management for Environmental Protection. HMSO, London, 1995.

DETR, EA & IEH (2000) Guidelines for Environmental Risk Assessment and Management. Department of the Environment, Transport and the Regions, Environment Agency, and the Institute of Environment and Health.

Environment Agency (2002) Guidance on the characterisation and remediation of radioactively contaminated land. Environment Agency, Rotherham.

Environment Agency (2004) Model Procedures for the Management of Land Contamination. Contaminated Land Report 11, Bristol.

Environment Agency (2006) Radioactive Contaminated Land - Briefing Note 3 Developing Land Contaminated with Radioactivity. Environment Agency, Rotherham.

Environment Agency (2009) Radioactive Substances Regulation - Environmental Principles. Environment Agency, Bristol.

Environment Agency (2011) Incidents and their classification: the Common Incident Classification Scheme (CICS). Operational Instruction 04_01 (September 2011)

European Commission (2000) Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community with in the field of water policy. Official Journal of the European Communities L 327/1.

Health and Safety Executive (2001a) Reducing Risks, Protecting People: HSE's Decision-Making Process.

Health and Safety Executive (2001b) Technical Assessment Guide – Management of Radioactive Materials and Radioactive Waste on Nuclear Licensed Sites, T/AST/024, Issue 003.

Health and Safety Executive (2005) HSE Criterion for delicensing nuclear sites. HSE, London.

Health and Safety Executive (2006) Safety Assessment Principles for Nuclear Facilities (2006 Edition, Revision 1, 2008).

Health and Safety Executive (2008) Guidance to Inspectors on the Interpretation and Implementation of HSE Policy Criterion of No Danger for Delicensing Nuclear Sites.

Health and Safety Executive (2011) Nuclear Site Licence Conditions.

Intergovernmental Panel on Climate Change (2007) IPPC Fourth Assessment Report Climate Change 2007 (AR4). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Cambridge.

Nathanail, C.P. et al. (2009). The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment. 2nd Edition. Land Quality Press, Nottingham.

National House-Building Council, Environment Agency & Chartered Institute of Environmental Health (2008) Guidance for the Safe Development of Housing on Land Affected by Contamination. R&D Publication 66, Volumes 1 & 2.

NRPB (1998) Radiological Protection Objectives for Land Contaminated with Radionuclides. Documents of the NRPB, 9 (2).

Scottish Environment Protection Agency (2011) Assigning groundwater assessment criteria for pollutant inputs. Position Statement WAT-PS-10-01, Version 2.1, June 2011.

Scottish Executive (2006) Environmental Protection Act 1990: Part 2A Contaminated Land. Second Edition, paper SE/2006/44, statutory guidance.

Scottish Government (2009) Radioactive Contaminated Land (Scotland) Amendment Regulations 2009 (SSI 202).

Scottish Government (2007a) Radioactive Contaminated Land (Scotland) Regulations 2007 (SSI 179).

Scottish Government (2007b) Environmental Protection Act 1990: Part 2A Contaminated Land. The Radioactive Contaminated Land (Scotland) Regulations 2007. Statutory Guidance. Paper SE/2007/168.

SNIFFER (2007). Environmental legislation and human health – Guidance for assessing risk. Land Quality Management Ltd. Project CC 02. SNIFFER, Edinburgh. http://www.sniffer.org.uk/Webcontrol/Secure/ClientSpecific/ResourceManagement/UploadedFiles/UKCC02 guidance.pdf

UK Government (2007) Radioactive Contaminated Land (Scotland) (Amendment) Regulations 2007 (SI 3240).

WAG (2006) Land Contamination: A Guide for Developers. Jointly with the Environment Agency and Welsh Assembly Government, Welsh Local Government Association.

Appendix 1 Legislative Context

A1.1 Land Affected by Radioactive Contaminants

A1.1.1 Land Affected by Radioactive Contaminants on a Nuclear Licensed Site

"Radioactively contaminated land" on a nuclear licensed site is defined in the Safety Assessment Principles (SAPs) (HSE, 2006) as land on which the radioactive contamination is such that it precludes the Health and Safety Executive (HSE) agreeing to its delicensing. Unless an authorised disposal under EPR10 or RSA93 is achieved, such land is considered by the ONR as an accumulation of nuclear matter, and requires the licensee to manage it within the provisions set out in the Nuclear Site Licence Conditions (HSE, 2011). Principles and guidance for managing radioactively contaminated land on a nuclear licensed site are described in SAPs (HSE, 2006) and Technical Assessment Guide T/AST/024 (HSE, 2001b).

Although delicensing land on a nuclear licensed site is not within the scope of this document, mention is made of delicensing criterion for completeness – not least because of the way the SAPs (HSE, 2006) define "radioactively contaminated land" (see above). In order to demonstrate that under the provisions of the Nuclear Installations Act (NIA65) there is "no danger" from ionising radiations from anything on, in or under the land that is to be delicensed, "any residual activity, above background radioactivity, which remains on the site, which may or may not have arisen from licensable activities, will lead to a risk of death to an individual on the site for any reasonably foreseeable purpose of no greater than one in a million per year" (HSE, 2005; HSE, 2008). The statement also notes that the overall requirements of the Health and Safety at Work Act 1974 (HSWA74) are to reduce risks "ALARP", and therefore HSE expects consideration of this overall principle, even for very low risks ($<10^{-6}$ y^{-1}). This may be as simple as licensees showing that there are no other inexpensive clean-up activities that could be carried out.

A1.1.2 Land Affected by Radioactive Contaminants Not on a Nuclear Licensed Site

In England, Wales and Scotland, radioactive land contamination which is not on nuclear licensed sites is managed under the extended EPA90 Part 2A contaminated land regime or by the Town and Country Planning system.

Under EPA90 Part 2A, radioactive contaminated land is defined as any land which as a result of a past practice, or work activity, appears to a Local Authority (LA) to be in such a condition, by reasons of substances in, on or under the land that harm is being caused, or there is the possibility of harm being caused. In the definition "harm" refers to the potential effects of long-lasting radiation exposure to humans. Land is then defined as radioactive contaminated land if the individual effective dose is equal to or greater than 3 mSv y^{-1} (and/or the dose to the skin is equal to or greater than 50 mSv y^{-1}, and/or the dose to the lens of the eye is equal to or greater than 15 mSv y^{-1} (Defra 2006)).

In Scotland, "radioactive contaminated land" is land which appears to the Scottish Environmental Protection Agency (SEPA) to be in such a condition, by reasons of substances in, on or under the land that significant harm is being caused, or there is a significant possibility of such harm being caused, or where significant pollution of the water environment is being caused, or there appears to be a significant possibility of such pollution being caused (Scottish Government 2009, 2007a, 2007b, UK Government, 2007). The definition of "harm" is the same as for England and Wales. Significant pollution of the water environment is defined as when:

- radionuclide concentrations are leading to significant harm to human beings;
- substances in the water environment are leading to significant harm to non-human species, where this is defined as dose rates above:
    - 400 µGy h^{-1} for aquatic biota or plants;
    - 40 µGy h^{-1} for terrestrial biota or plants.

In this context, "substance" has a particular radiological definition, which is in addition to its definition under the non-radioactive contaminated land regime.

One of the provisions of the extension of Part 2A to cover radioactive contamination is that land identified as radioactively contaminated is classified as a "special site". Usually the LA is expected to make the initial decision on whether the land is a "special site", although the regulator can initiate matters by issuing a notice to the LA. If the land is identified as a "special site" then regulation is referred to the appropriate environmental agency.

Part 2A has been further extended to include "land contaminated by a nuclear occurrence", which the earlier extension had excluded from the scope. In broad terms the amendment to the regulations covers radioactive contamination from licensed nuclear sites, which is outside the boundary of a nuclear licence and certain other situations.

Under the Town and Country planning regime, the management of land contaminated with radioactivity is the responsibility of the developer, who has to meet any conditions set in the planning permission granted by the LA. The minimum requirement for redevelopment of a site is that the new use should not give rise to doses above 0.3 mSv y^{-1}. This is subject to an assessment of exposure to future occupants and to people undertaking the remediation to ensure that this is As Low As Reasonably Achievable (ALARA), taking into account social and economic considerations (EA, 2006).

The environment agencies regulate the management of any radioactive wastes produced and advise local authorities and developers on radioactive waste management matters (EA, 2002; EA, 2006; EA, 2009). Local Authorities are also expected to take account of the views of the Health Protection Agency (HPA) for situations involving a change of land use (NRPB, 1998).

The main differences between EPA90 Part 2A the Town and Country Planning system for radioactive land contamination is as follows:

- under EPA90 Part 2A, the risks from a site in its current condition are considered and potential exposure is assessed relative to "intervention" dose criteria;
- under the Town and Country Planning system, the proposed "new" use is considered, and the risks assessed relative to the new use using "practice" dose criteria (which, for doses to humans, are lower than intervention criteria). If above the practice criteria then the developer should remediate to a level which is ALARA, using justification and optimisation arguments.

A1.2 Land Affected by Chemical Contaminants

EPA90 Part 2A and the Town and Country Planning system are central to the regulation of chemically contaminated land in the UK. EPA90 Part 2A together with the relevant Contaminated Land regulations for chemical contamination and statutory guidance for England, Scotland and Wales introduced a statutory regime for the identification and remediation of chemically contaminated land that enshrined the principles of "polluter pays" and "suitable for use".

In regard to any area of chemical contamination on a nuclear licensed sites being determined as "contaminated land", such land would be determined as a "special site" under EPA90 Part

2A, and the appropriate environment agency would then become the main regulator for the chemical contamination. The HSE and ONR will also regulate safety (from all causes).

Under EPA90 Part 2A, land impacted by chemical contaminants which is causing, or is likely to cause significant harm, or pollution of controlled waters/ water environment requires remediation (Defra, 2006; Scottish Executive, 2006; WAG, 2006). Voluntary remediation is encouraged, but the environment agencies can issue a remediation notice to enforce remedial action if necessary.

Outside of the licensed site the management of land chemically contaminated is controlled by either the EPA90 Part 2A regime or the Town and Country Planning system. Under the EPA90 Part 2A regime, LAs are required to identify the contaminated land in their area according to the legal definition of contaminated land. In England and Wales the legal definition of contaminated land is:

"Land which appears to the authority to be in such a condition, by reason of substances in, on or under it that either:

- significant harm is being caused or there is a significant possibility of such harm being caused; or
- pollution of controlled waters is being caused or is likely to be caused."

The definition of contaminated land in Scotland differs from this since the introduction of the Contaminated Land (Scotland) Regulations 2005. These regulations were introduced with the purpose to primarily:

- prevent disproportionate regulation being applied to contaminated land causing only trivial amounts of pollution to the water environment; and
- to align the contaminated land regime and the relevant provisions of the Water Environment and Water Services (Scotland) Act 2003.

Therefore, in Scotland contaminated land is defined as:

"any land which appears to the LA in whose area it is situated to be in such a condition, by reason of substances in, on or under the land that:

- significant harm is being caused or there is a significant possibility of such harm being caused; or
- significant pollution of the water environment is being caused or there is a significant possibility of such pollution being caused."

If the land is defined as contaminated then action is required to ensure that the land in its current use is no longer "contaminated land", and that the effects of any significant harm or pollution are remedied. This action will usually take the form of "remediation" with the standard of "remediation" required defined the LA, which will be implemented under voluntary remediation or under a remediation notice.

The EPA90 Part 2A regime is designed to encourage voluntary remediation with the cost often funded by redevelopment of the land, and in such cases the planning system will ensure that the contaminated land is investigated properly and that remediation is carried out.

The Town and Country Planning system is the land use planning system governments use to balance economic development and environmental quality. Each country of the United Kingdom has its own planning system that is responsible for Town and Country Planning and

controls how people develop and use land. Local Planning Authorities are responsible for making sure that planning requirements are met. Land contamination is a “material planning consideration”. This means a planning authority must consider contamination when preparing development plans or considering individual planning applications.

Local planning authorities are responsible for ensuring land contamination is dealt with through the planning system and remediation (clean-up) takes place where required. The developer is responsible for carrying out the necessary remediation to an agreed acceptable standard. In carrying out their duties the local planning authority will consult with other statutory bodies such as the EA and SEPA. If they are consulted, then EA/SEPA can only comment on areas where they have regulatory responsibility. As a minimum, after carrying out a development and commencement of its use, the land should not be capable of being determined as contaminated land under EPA90 Part 2A.

Both the EPA90 Part 2A regime and Town and Country Planning system are focused on land that has been contaminated by previous activities. However, a range of other regulatory regimes also deal with contaminated land, which have been introduced to prevent new contamination. These regimes have been transposed into legislation through the following regulations:

- EPR10 in England and Wales, and Pollution, Prevention and Control (Scotland) Regulations 2000 (PPC) and Waste Management Licensing (Scotland) Regulations 2011 in Scotland;
- Provisions of RSA93 (in England and Wales transferred into Environmental Permitting);
- NIA65;
- Water Resources Act 1991 in England and Wales;
- Water Environment and Water Services (Scotland) Act 2003 and Water Environment (Controlled Activities) (Scotland) Regulations 2005, 2011;
- Environmental Damage (Prevention and Remediation) Regulations 2009 in England and Wales, and Environmental Liability (Scotland) Regulations 2009 in Scotland;
- Environmental Protection Act 1990 Part 3 (Statutory Nuisance); and
- Environment Act 1995 Schedule 22 (Works Notice powers).

The EPA90 Part 2A regime only applies in instances where contamination/pollution is not regulated by other controls such as EPR10/PPC or Environmental Damage/Liability. If the EPA90 Part 2A regime is deemed applicable then liability is retrospective and is not limited in time.

A1.3 Land Affected by Mixed Contamination

Where mixed contamination (radioactive and chemical) is present within a nuclear licensed site’s boundary then the land is jointly regulated by the HSE and relevant environmental agency. The land is managed using the regimes for radioactive land contamination and non-radioactive land contamination (NIA65, HSWA74, IRR99, RSA93, EPA90 Part 2A, and planning).

Outside the nuclear licensed site boundary land affected by mixed contamination is regulated by the environment agencies and the LA. For land where there is no planned change in land use EPA90 Part 2A applies, but for those planned to be redeveloped then the planning system applies with any remediation wastes regulated by the appropriate environmental agency.

Appendix 2 Comparison of Descriptors of Severity of Consequence, Likelihood of Consequence Occurring and Significance of Risk, in this and Previous Guidance

Table A2.1. Comparison of definitions of "Severity of Consequence"

	CIRIA (2001)				Defence Estates (2007)			
	Minor	**Mild**	**Medium**	**Severe**	**Negligible**	**Mild**	**Moderate**	**Severe**
Harm to humans (health risks from non-radioactive contamination)	Non-permanent health effects to human health (easily prevented by means such as PPE)	Not defined	Chronic damage to human health ("significant harm")	Short-term (acute) risk to human health likely to result in "significant harm" as defined by Part 2A	No measurable effect on humans	Slight short-term health effects to humans	Non-permanent health effects to humans	Damage to human health
Harm to flora and fauna	Not defined	Damage to the environment	A significant change in a particular ecosystem, or organism forming part of such ecosystem	A short-term risk to a particular ecosystem, or organism forming part of such ecosystem	No significant changes to population densities in the environment or in any ecosystem	Some changes to population densities but with no negative effects on the function of the ecosystem	A change to population densities of non-sensitive species	A significant change to the number of one or more species or particular ecosystem(s)
Harm to property (excluding buildings)	Not defined	Significant damage to crops	Not defined	Catastrophic damage	Not defined	Not defined	Not defined	Not defined
Harm to buildings	Easily repairable effects of damage to buildings, structures and services	(Significant) damage to sensitive buildings / structures / services	Not defined	Catastrophic damage	Very slight non-structural damage or cosmetic harm to buildings or structures	Easily repairable effects of damage to buildings and structures	Damage to sensitive buildings, structures or the environment	Irreparable damage to buildings, structures or the environment
Pollution of the water environment including any potable abstraction points	Not defined	Pollution of non-sensitive water resources	Pollution of sensitive water resources	Short-term risk of pollution of sensitive water resources	Insubstantial pollution to non-sensitive water resources	Slight pollution to non-sensitive water resources	Pollution of non-sensitive water resources or small-scale pollution of sensitive water	Substantial pollution of sensitive water resources

	NHBC, EA & CIEH (R&D66:2008)				This guidance			
	Minor	**Mild**	**Medium**	**Severe**	**Negligible**	**Mild**	**Moderate**	**Severe**
Harm to humans (health risks from non-radioactive contamination) [26]	No measurable effect on humans	Exposure to human health unlikely to lead to "significant harm"	Elevated concentrations which could result in "significant harm" to human health as defined for the EPA 1990, Part 2A if exposure occurs	Highly elevated concentrations likely to result in "significant harm" to human health as defined for the EPA 1990, Part 2A if exposure occurs	People being exposed to contaminants in soil or other media at levels that represent negligible/minimal risk to human health. No perceptible nuisance. If quantitative data were available, this could be demonstrated by non-exceedance of background/normal levels, or GACs[27] for threshold substances.	People being exposed to contaminants in soil or other media at levels with acceptably low likelihood of leading to "significant harm" to human health as defined for the EPA90, Part 2A[28] ["Acceptably low likelihood" of significant harm being in the situation of people actually being exposed]. Or perceptible nuisance (e.g. VOC odour). If quantitative data were available, this could be compatible with slight or localised exceedances of background levels or GACs.	People being exposed to contaminants in soil or other media at levels giving rise to reasonable concern about the possibility of "significant harm" to human health as defined for the EPA90, Part 2A, but not indicative of SPOSH[29] ["Reasonable concern" about the possibility of significant harm being in the situation of people actually being exposed]. If quantitative data were available, this could be indicated by widespread substantial exceedances of GACs.	People being exposed to contaminants in soil or other media at levels that could reasonably be construed as indicative of SPOSH (significant possibility of significant harm) to human health as defined for the EPA90, Part 2A [SPOSH being in the situation of people actually being exposed]. If quantitative data were available, this could be indicated by widespread gross exceedances of GACs.

[26] See discussion in Section 2.5.1.1 for the reasons for using different definitions from those in R&D66:2008.
[27] GAC sources include EA SGVs, LQM/CIEH GACs (Nathanail et al. 2009), EIC/CL:AIRE GACs.
[28] i.e. "Death, disease, serious injury, genetic mutation, birth defects or impairment of reproductive functions" (Defra, 2006).
[29] SPOSH = "significant possibility of significant harm" as defined in Part 2A of the Environmental Protection Act and relevant statutory guidance in England, Scotland and Wales.

	NHBC, EA & CIEH (R&D66:2008)				This guidance			
	Minor	**Mild**	**Medium**	**Severe**	**Negligible**	**Mild**	**Moderate**	**Severe**
Harm to flora and fauna	Not defined separately from water environment for which "no observed effect on ecosystems" is included	Minor or short-lived damage to aquatic or other ecosystems, which is unlikely to result in a substantial adverse change in its functioning or harm to a species of special interest that would endanger the long-term maintenance of the population	Significant damage to aquatic or other ecosystems, which may result in a substantial adverse change in its functioning or harm to a species of special interest that may endanger the long-term maintenance of the population	Major damage to aquatic or other ecosystems, which is likely to result in a substantial adverse change in its functioning or harm to a species of special interest that endangers the long-term maintenance of the population	Any ecological system or living organism forming part of such a system being exposed to contaminants in soil or other media at levels that could not lead to "significant harm" to an ecological system as defined for the EPA90, Part 2A[30].	Any ecological system or living organism forming part of such a system being exposed to contaminants in soil or other media at levels with acceptably low likelihood of leading to "significant harm" to an ecological system as defined for the EPA90, Part 2A ["Acceptably low likelihood" of significant harm being in the situation of an ecological system actually being exposed].	Any ecological system or living organism forming part of such a system being exposed to contaminants in soil or other media at levels giving rise to reasonable concern about the possibility of "significant harm" to an ecological system as defined for the EPA90, Part 2A, but not indicative of SPOSH ["Reasonable concern" about the possibility of significant harm being in the situation of an ecological system actually being exposed].	Any ecological system or living organism forming part of such a system being exposed to contaminants in soil or other media at levels that could reasonably be construed as indicative of SPOSH to an ecological system as defined for the EPA90, Part 2A [SPOSH being in the situation of an ecological system actually being exposed].

[30] i.e. "For any protected location: harm which results in an irreversible adverse change, or in some other substantial; adverse change, in the functioning of the ecological system within any substantial part of that location or harm which effects any species of special interest within that location and which endangers the long-term maintenance of the population of that species at that location" (Defra, 2006).

	NHBC, EA & CIEH (R&D66:2008)				This guidance			
	Minor	**Mild**	**Medium**	**Severe**	**Negligible**	**Mild**	**Moderate**	**Severe**
Harm to property (excluding buildings)	Repairable effects of damage to buildings, structures and services	Minor damage to crops, buildings or property	Significant damage to crops, buildings or property	Catastrophic damage to crops, buildings or property	Animals or crops being exposed to contaminants in soil or other media at levels that could not lead to "significant harm" to animals or crops as defined for the EPA90, Part 2A[31].	Animals or crops being exposed to contaminants in soil or other media at levels with acceptably low likelihood of leading to "significant harm" to animals or crops as defined for the EPA90, Part 2A ["Acceptably low likelihood" of significant harm being in the situation of animals or crops actually being exposed].	Animals or crops being exposed to contaminants in soil or other media at levels giving rise to reasonable concern about the possibility of "significant harm" to animals or crops as defined for the EPA90, Part 2A, but not indicative of SPOSH. ["Reasonable concern" about the possibility of significant harm being in the situation of animals or crops actually being exposed].	Animals or crops being exposed to contaminants in soil or other media at levels that could reasonably be construed as indicative of SPOSH to animals or crops as defined for the EPA90, Part 2A [SPOSH being in the situation of animals or crops actually being exposed].
Harm to buildings					Buildings being exposed to contaminants in soil or other media at levels that could not lead to "significant harm" to buildings as defined for the EPA90, Part 2A[32]	Buildings being exposed to contaminants in soil or other media at levels with acceptably low likelihood of leading to "significant harm" to buildings as defined for the EPA90, Part 2A ["Acceptably low likelihood" of significant harm	Buildings being exposed to contaminants in soil or other media at levels giving rise to reasonable concern about the possibility of "significant harm" to buildings as defined for the EPA90, Part 2A, but not indicative of SPOSH. ["Reasonable	Buildings being exposed to contaminants in soil or other media at levels that could reasonably be construed as indicative of SPOSH to buildings as defined for the EPA90, Part 2A [SPOSH being in the situation of buildings actually

[31] i.e. "For crops, a substantial diminution in yield or other substantial loss in their value resulting from death, disease or other physical damage. For domestic pets, death, serious disease or serious physical damage. For other property in this category, a substantial loss in its value resulting from death, disease or other serious physical damage".
[32] i.e. "Structural failure, substantial damage or substantial interference with any right of occupation" (Defra, 2006).

	NHBC, EA & CIEH (R&D66:2008)				This guidance			
	Minor	**Mild**	**Medium**	**Severe**	**Negligible**	**Mild**	**Moderate**	**Severe**
						being in the situation of buildings actually being exposed].	Concern" about the possibility of significant harm being in the situation of buildings actually being exposed].	being exposed].
Pollution of the water environment, including any potable abstraction points[33,34,35]	Equivalent to insubstantial pollution incident with no observed effect on water quality [or ecosystems]	Equivalent to EA Category 3 pollution incident including minimal or short lived effect on water quality; marginal effect on amenity value, agriculture or commerce	Equivalent to EA Category 2 pollution incident including significant effect on water quality; notification required to abstractors; reduction in amenity value or significant damage to agriculture or commerce	Equivalent to EA Category 1 pollution incident including persistent and/or extensive effects on water quality; leading to closure of potable abstraction point; major impact on amenity value or major damage to agriculture or commerce	"Negligible" pollution is what a regulator would typically regard as a potentially discernible but inconsequential effect, such as: • Contaminants of concern detectable in a water environment receptor at levels indistinguishable from local background levels. • Contaminants of concern detectable in groundwater in unproductive strata (or non-groundwater body in Scotland), but	"Mild" pollution is what a regulator would typically regard as a discernible but "minimal" effect, such as: • A borderline Category 3/4 incident affecting surface water, as defined in the EA's CICS. [See Appendix A.3.1]. • Contaminants of concern detectable in groundwater in aquifer strata, but below applicable water quality standards. • A borderline Category 3/4	"Moderate" pollution is what a regulator would typically regard as a borderline "minimal"/"significant" effect, such as: • A Category 3 incident affecting surface water, as defined in the EA's CICS. [See Appendix A.3.1]. • Contaminants of concern detectable in groundwater above applicable water quality standards in groundwater in aquifer strata, but not reaching a relevant	"Severe" pollution is what a regulator would typically term a "significant" or "major" effect on a water environment receptor, such as: • A Category 1 or 2 incident affecting surface water, as defined in the EA's CICS. [See Appendix A.3.1]. • Significant pollution of groundwater, as might be determined under Part 2A of EPA90.[24] • A Category 1 or 2 incident affecting a potable abstraction,

[33] "Water" includes surface waters (inland freshwaters, coastal waters and relevant territorial waters as defined in Section 104 of the Water Resources Act 1991) and groundwater (all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil).
[34] EA incident categories are from the Common Incident Classification Scheme (CICS) (EA, 2011).
[35] SEPA document "WAT-PS-10-01" is SEPA's Position Statement on "Assigning groundwater assessment criteria for pollutant inputs" (SEPA, 2011).

	NHBC, EA & CIEH (R&D66:2008)				This guidance			
	Minor	**Mild**	**Medium**	**Severe**	**Negligible**	**Mild**	**Moderate**	**Severe**
					below applicable water quality standards (e.g. SEPA Resource Protection Values).	incident affecting a potable abstraction, as defined in the EA's CICS. [See Appendix A.3.2].	compliance point.[36] • A Category 3 incident affecting a potable abstraction, as defined in the EA's CICS. [See Appendix A.3.2].	as defined in the EA's CICS. A Category 2 incident is defined as "Significant effect on a potable abstraction point". [The definition of "significant" in this context is given in Appendix A.3.2]

[36] Guidance on compliance points and criteria in Scotland are found in SEPA's document WAT-PS-10-01 (particularly Figure 4), and will be given in Part 5 of EA's document Groundwater Protection: Principles and Practice, due out in 2012.

Table A2.2. Comparison of definitions of "Likelihood of Consequence Occurring"

Defence Estates PG 01/07 (2007)		IPCC (2007)		This guidance	
Certain	100%	Virtually certain	> 99% probability	Very Likely / Certain	> 95%
Almost certain	95-99%	Almost certain	> 95% probability		
Likely or probable	55-94%	Very likely	> 90% probability	Likely	45 – 95%
		Likely	> 66% probability		
Possible, or as likely as not	45-54%	More likely than not	> 50% probability		(NB overlapping ranges in IPCC terms)
		About as likely as not	33 to 66% probability		
Unlikely or improbable	5-44%	Unlikely	< 33% probability	Unlikely	5 – 44%
		Very unlikely	< 10% probability		
Nil chance	0-4%	Extremely unlikely	< 5% probability	Very unlikely	< 5%
		Exceptionally unlikely	< 1% probability		
				Extremely unlikely	<< 1%

Table A2.3. Comparison of definitions of "Significance of Risk"

NHBC, EA & CIEH (R&D66:2008)					This guidance					
	High Likelihood	**Likely**	**Low Likelihood**	**Unlikely**		**Very Likely/ Certain**	**Likely**	**Unlikely**	**Very Unlikely**	**Extremely Unlikely**
Severe	Very High	High	Moderate	Moderate/ Low	**Severe**	Very High	Very High	High	Medium	Low
Medium	High	Moderate	Moderate/ Low	Low	**Moderate**	High	High	Medium	Low	Very Low
Mild	Moderate	Moderate/ Low	Low	Very Low	**Mild**	Medium	Medium	Low	Very Low	Trivial
Minor	Low	Low	Very Low	Very Low	**Negligible**	Low	Very Low	Very Low	Trivial	Trivial

Note: CIRIA (2001) definitions are identical to those of NHBC, EA & CIEH (2008) except for High Likelihood of Minor Consequence – "Moderate/Low" in CIRIA (2001).

Appendix 3 Environment Agency "Common Incident Classification Scheme" – Definitions of Terms within Incident Category Definitions Used in Table 5

A.3.1 Definitions relevant to Incidents affecting surface water quality

Category 1 Incident: "Major effect on water quality: A persistent and/or extensive effect on water quality which has a serious effect on the quality or use of that water".

- For **surface water**, "persistent" means an effect is still evident at least 7 days from the date that contamination enters the water.
- For **surface waters,** "extensive" means an effect over several kilometres of a watercourse or a large area of a still water or coastal waters. As a guide, use 1-2km, but some subjectivity may be applied. For example, a major deterioration in water quality or covering of silt over half a kilometre on a large important river (such as the lower Severn or Thames) would be a Category 1 incident.
- For **surface waters**, "serious" effects include levels of dangerous substance(s) exceeding toxicity levels known to cause serious harm/death to aquatic life or dissolved oxygen levels falling to critical levels. It would not include minor impacts such a slight drop in dissolved oxygen levels even if they extend over several kilometres.

Category 2 Incident: "Significant effect on water quality: Significant but normally localised effect on water quality which has a significant impact on the quality or use of that water".

- For **surface waters**, examples of Category 2 impacts include silt or soil, low dissolved oxygen or high ammonia levels along an extensive stretch of a water body. Impacts may be up to a couple of hundred metres in a larger water body or effects over several kilometres (such as a heavy rainbow coloured oil film).

Category 3 Incident: "Minimal effect on water quality: Limited and localised effect on water quality which has a minimal impact on the quality or use of that water".

- For **surface waters**, impacts are normally localised around the point of discharge, but could include an impact extending over a few kilometres of a stream (such as a thin oil sheen).

Category 4 incident: "No impact: Substantiated incident with no impact to water quality" [37].

A.3.2 Definitions relevant to Incidents affecting potable abstraction points

Category 1 (Major)

- Necessary closure of a strategically important potable surface or groundwater abstraction, to prevent contamination or further contamination of that source, due to an actual deterioration in water quality.

[37] In the Q_LRA context, this means there is no pollutant linkage, therefore no consequence; hence not used as an example of a severity of consequence descriptor.

- For strategic groundwater sources the impact is likely to be less immediate but closure of the abstraction may be no less justified if the incident occurs within a Source Protection Zone.
- Do not apply Category 1 [major] if the closure of an abstraction is precautionary.

Category 2 (Significant)

- Precautionary closure of a strategically important potable surface or groundwater abstraction to prevent contamination of that source.
  - Apply Category 2 to the precautionary closure of a strategic groundwater abstraction where the incident did not fall within its nature conservation source protection zone.
- Necessary closure of a minor unlicensed potable surface or groundwater abstraction (such as serving one or two households) due to an actual deterioration in water quality.
- Significant action or treatment required by the operator to address a deterioration in water quality, such as blending with uncontaminated water.

Category 3 (Minor)

- Precautionary closure of an unlicensed potable groundwater or surface water abstraction.
- Minor action or treatment required by the operator to address a deterioration in water quality.

Category 4 (No impact)

- Substantiated incident with no impact to abstractions[38].

[38] In the Q_LRA context, this means there is no pollutant linkage, therefore no consequence; hence not used as an example of a severity of consequence descriptor.

Appendix 4 Examples of Possible "Next-Steps" Actions Following Qualitative Risk Assessment

The following table presents suggestions by the authors of this document as to how problem-holders might take the risk management process forward following application of this Q_LRA methodology, particularly for situations where the qualitative risk assessment (rather than other processes such as nuclear safety assessment, ALARP assessment or BAT/BPM assessment) appropriately provides the main input to decision-making at a particular point in the process of managing the contamination.

When considering "next steps" actions, account should be taken of site-wide control measures that already apply, such as land use restrictions, procedural controls for excavations, and ensuring records of the status of the land are kept and maintained.

Table A4.1: Possible "Next-Steps" Actions Based on Significance of Risk

SIGNIFICANCE OF RISK	SUGGESTIONS FOR IMMEDIATE ACTIONS (Short Term Risks)	SUGGESTIONS FOR SUBSEQUENT ACTIONS (Short & Long Term Risks)
Very High	Immediate effective interim action should be taken (if possible) to mitigate the risk without delay. Work towards specifying more permanent remedial action should be initiated (including appropriate information-gathering). If confidence in the assessment is Low and the risk assessment is thought to be highly conservative, it may be more appropriate to undertake further information-gathering to reduce conservatisms in the risk assessment (qualitative or quantitative) before initiating remedial action.	Undertake remediation via an options appraisal, or further tiers of risk assessment, with supporting information-gathering, if confidence in the assessment is "Low" (as defined in Table 4).
High	Risks should be mitigated by effective interim remedial action within a reasonably prompt timescale appropriate to the nature of the risk. Caveats stated for "Very High" risks also apply.	Undertake remediation via an options appraisal assessment, or further tiers of risk assessment (with supporting information-gathering if uncertainty exists in the assessment.
Medium	Consideration should be given to whether interim remedial action should be implemented before further information-gathering and risk assessment is undertaken.	Undertake further of risk assessment (with supporting information-gathering), or remediation via an options appraisal assessment.
Low	No immediate action required, other than to keep land quality under surveillance and undertake periodic review to ensure that the assumptions and inputs to the original qualitative risk assessment remain valid.	Consider current mitigation of risks and whether the risk significance can be further reduced by readily implementable additional measures. Consider the confidence in the risk assessment, and whether further information is required to justify the "Low" risk more robustly (especially if confidence is "Low", as defined in Table 4).

SIGNIFICANCE OF RISK	SUGGESTIONS FOR IMMEDIATE ACTIONS (Short Term Risks)	SUGGESTIONS FOR SUBSEQUENT ACTIONS (Short & Long Term Risks)
Very Low	As for “Low” significance risks.	Consider the confidence in the risk assessment, and whether further information is required to justify the “Very Low” risk more robustly (especially if confidence is “Low”, as defined in Table 4).
Trivial	As for “Low” significance risks.	No further actions needed, unless, or until, site conditions change.