Radiological protection of the environment: providing knowledge and skills to the user community

INTRODUCTION TO ENVIRONMENTAL RADIOLOGICAL PROTECTION

Objective of this briefing note

This document aims to provide a basic, brief and introductory overview to environmental radiological protection and the roles and relevant documents of the major international organisations. More information will be provided in all of the course lectures. Key references are provided for further reading and the major international documents relevant to the topic are listed for each organisation.

Why do we need environmental radiological protection?

For many years, protection of the environment from radiation was based on a statement issued by the International Commission on Radiological Protection (ICRP) which stated that: "*The Commission believes that the standard of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk. Occasionally, individual members of non-human species might be harmed, but not to the extent of endangering whole species or creating imbalance between species. At the present time, the Commission concerns itself with mankind's environment only with regard to the transfer of radionuclides through the environment, since this directly affects the radiological protection of man*" (ICRP, 1991, Para. 16).

The Commission's subsequent initial review of the protection of the environment as set out in Publication 91 (ICRP, 2003), concluded that there was a need for a broad international basis for evaluating and managing the actual or potential impact of radiation on the environment. It also concluded that there was a need to develop a comprehensive approach to the study of the effects on, and protection of, biota.

The need for a system capable of demonstrating that the environment is adequately protected from the effects of radioactive substances has subsequently been recognised by international organisations (e.g. IAEA) and a number of national regulators. There are various reasons for this change but key among them is the need to demonstrate that the environment is protected. However, radiological protection has not always been the driver of this process, in some countries a system of protection is required to address conservation legislation.

Over the last decade systems of radiological protection for wildlife have begun to evolve with considerable international and national effort on this issue.

The key international organisations input into environmental radiological protection

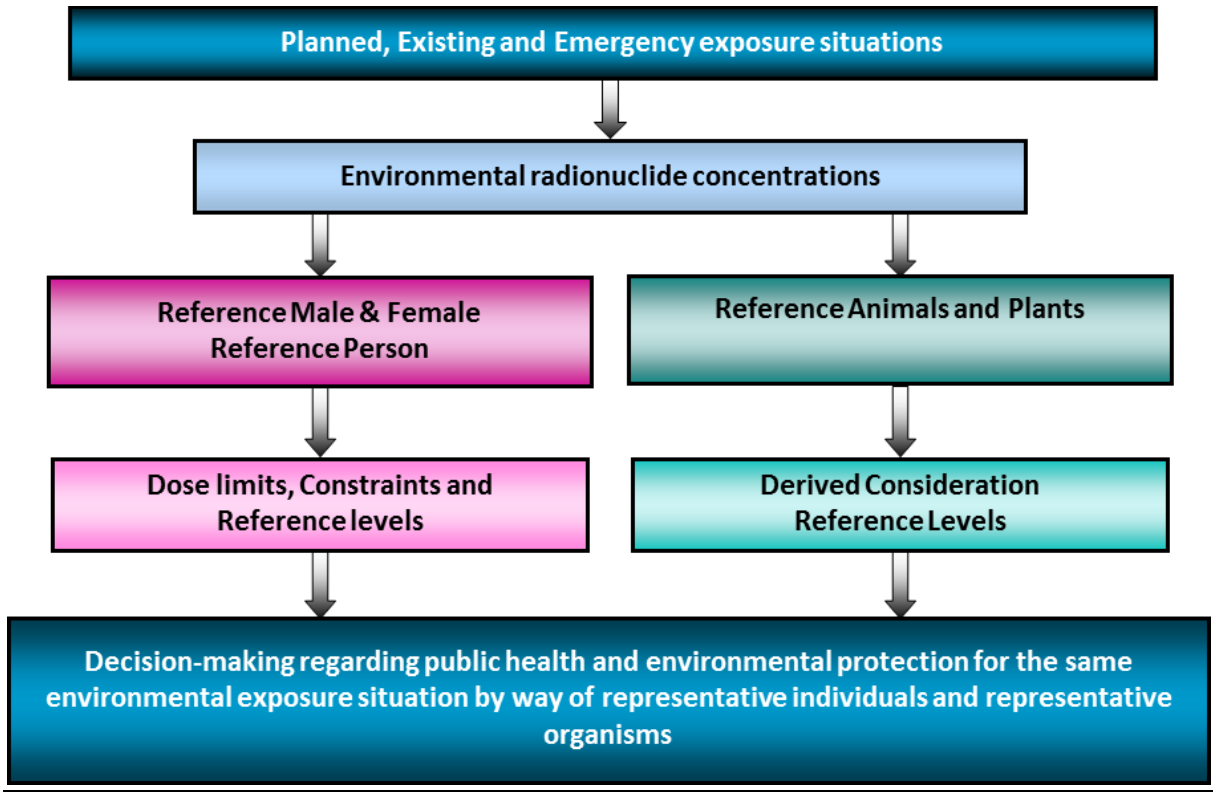
Warning: The text in the documents of the organisations considered below should be looked at very carefully: frequently insufficient attention is paid to the exact words and meaning when quoting and comparing.

The International Commission on Radiological Protection (ICRP)

The ICRP develops, maintains, and elaborates the International System of Radiological Protection used world-wide as the common basis for radiological protection standards, legislation, guidelines, programmes, and practice. In the 2007 recommendations of the ICRP, the Committee recommended the explicit consideration of Radiological Protection of the Environment and recognised the need for advice and guidance, including a clearer framework.

Between 2005 and 2017, the ICRP had a fifth Committee, which dealt specifically with the protection of the environment from ionising radiation. It aimed to ensure that the development and application of approaches to environmental protection are compatible with those for radiological protection of man, and with those for protection of the environment from other potential hazards.

Committee 5 published a report in 2009 which discussed a framework for protection of the environment which used the concept of Reference Animals and Plants (RAPs) that were designed to be compatible with the system of radiological protection used for humans. The similarity of the approach is envisaged to follow the scheme given by the ICRP shown below:



In publication 108, a Reference Animal or Plant was described as follows:

- "*A Reference Animal or Plant is a hypothetical entity, with the assumed basic biological characteristics of a particular type of animal or plant, as described to the generality of the taxonomic level of family, with defined anatomical, physiological, and life-history properties, that can be used for the purposes of relating exposure to dose, and dose to effects, for that type of living organism*."

It also defined Derived Consideration Reference Levels (DCRLs) for the Reference Animals and Plants as:

- "*A band of dose rate within which there is likely to be some chance of deleterious effects of ionising radiation occurring to individuals of that type of RAP (derived from a knowledge of expected biological effects for that type of organism) that, when considered together with other relevant information, can be used as a point of reference to optimise the level of effort expended on environmental protection, dependent upon the overall management objectives and the relevant exposure situation*."

ICRP Committee 5 task groups have also published reports on the transfer of radionuclides which gives concentration ratios for a wide range of elements for the Reference Animals and Plants (ICRP, 2009),

Key ICRP publications

Referencing to ICRP documents is often difficult to follow as confusion arises over recommendation years, publication number and Annals number. The four most relevant documents that may be referred to for environmental protection are listed below:

ICRP 1990 Recommendations of the International Commission on Radiological Protection *ICRP Publication* 60 (*Ann. ICRP* **21 (**1–3) 1991). *Superseded by ICRP Publication 103*

ICRP 2003. A Framework for Assessing the Impact of Ionising Radiation on Non-Human Species. *ICRP Publication* 91. (*Ann. ICRP* **33** (3) 2003).

ICRP 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. (*Ann. ICRP* **37** (2–4) 2007).

ICRP 2008 Environmental protection: the Concept and Use of Reference Animals and Plants. ICRP Publication 108. (*Ann. ICRP* **38** (4–6) 2008).

ICRP 2009 Environmental Protection: Transfer Parameters for Reference Animals and Plants. (*Ann.ICRP*, **39** (6) 2011).ICRP 2014 Protection of the Environment under Different Exposure Situations. ICRP Publication 124 (Ann. ICRP 43(1) 2014).

ICRP 2017 Dose Coefficients for Non-human Biota Environmentally Exposed to Radiation. ICRP Publication 136 (Ann. ICRP 46(2) 2017).

All the above can be accessed via the new ICRP web link: http://www.icrp.org/publications.asp

Some useful references which track the development of environmental radiological protection are a series of papers by Pentreath, a former chair of the ICRP's Committee 5 on Environmental Protection.

Pentreath, R.J., 1999. A system for radiological protection of the environment: some initial thoughts and ideas. J. Radiol. Prot. 19, 117–128.

Pentreath, R.J.,Woodhead, D.S., 2001. A system for protecting the environment from ionising radiation: selecting reference fauna and flora, and the possible dose models and environmental geometries that could be applied to them. Sci. Total Environ. 277, 33–43.

Pentreath, R.J., 2005. Concept and use of reference animals and plants. In: Protection of the Environment from the Effects of Ionising Radiation, IAEA-CN-109. IAEA, Vienna, pp. 411–420.

Pentreath R.J. 2009 Radioecology, radiobiology, and radiological protection: frameworks and fractures Journal of Environmental Radioactivity 100, 1019–1026.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)

UNSCEAR reports to the General Assembly of the United Nations (UN). It assesses global levels and effects of ionising radiation and provides the scientific basis for radiological protection. Governments and organisations rely on the Committee's information as the scientific basis for evaluating radiation risk and establishing protective measures.

UNSCEAR produced a report of the effects of Radiation on the Environment in 1990 based on limited data which was updated in 2008.

Key UNSCEAR publications

UNSCEAR 1996 Effects of radiation on the environment *United Nations Scientific Committee on the Effects of Atomic Radiation, Report to the General Assembly. Annex 1* (New York: United Nations).

http://www.unscear.org/unscear/en/publications/1996.html

UNSCEAR 2008 Sources and effects of ionizing radiation United Nations Scientific Committee on the Effects of Atomic Radiation, Report to the General Assembly. Volume II Scientific annexes C, D, E. (New York: United Nations).

http://www.unscear.org/unscear/en/publications/2008_2.html

The International Atomic Energy Agency (IAEA)

The IAEA has unique statutory responsibilities within the UN for:

- Establishing standards of radiation safety (and by implication also for environmental protection)
- Providing technical assistance for the application of the standards at the request of any state

One of the tasks of the IAEA in developing safety standards is to transform ICRP Recommendations into practical guidance. In doing so, the standards should contribute to the safety objectives as well as the fundamental safety principles of the IAEA. The IAEA's safety objective now states "*The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation*." Furthermore, the IAEA has revised one of its central Safety Requirements, the International Basic Safety Standards (BSS) (IAEA 2006) so that it nowrefers to environmental protection from ionising radiation. The International Basic Safety Standards explicitly requires the consideration of protection of people and the environment with respect to registration, licensing and setting discharge limits. In addition, protection of the environment is identified as an issue to consider during optimization in existing and emergency exposure situations. There are Safety Guides and a Safety report being developed to assist member states with respect to the new BSS. For example, General Safety Guide No. GSG-8.

Key relevant IAEA publications

IAEA 1995 The principle of radioactive waste management. Waste Safety Fundamentals Safety Series No. 111-F. IAEA, Vienna.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub989e_scr.pdf

IAEA 1996 International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115. IAEA, Vienna.

http://www-pub.iaea.org/MTCD/publications/PDF/SS-115-Web/Start.pdf

IAEA 2000 Regulatory control of radioactive discharges to the environment. Safety Standards Series No. WS-G-2.3. IAEA, Vienna.

http://www-pub.iaea.org/MTCD/publications/PDF/P088_scr.pdf

IAEA 2001.Generic models for use in assessing the impact of discharges if radioactive substances in to the environment. Safety Series reports No. 19. IAEA: Vienna

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1103_scr.pdf

IAEA 2002. Ethical Considerations in Protecting the Environment from the Effects of Ionizing Radiation: A report for discussion. IAEA-TECDOC-1270, IAEA, Vienna.

http://www-pub.iaea.org/MTCD/publications/PDF/te_1270_prn.pdf

IAEA 2006 Fundamental Safety principles. IAEA Safety Standards Series No SF-1. IAEA: Vienna.

http://www-pub.iaea.org/mtcd/publications/PubDetails.asp?pubId=7592

IAEA 2014 Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. General Safety Requirements. No. GSR Part 3. IAEA: Vienna.

https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf

IAEA (2018) Radiation Protection of the Public and the Environment. General Safety Guide No. GSG-8. IAEA, Vienna.

European Commission (EC)

The legal basis on which the EC provides for radiological protection under the Euratom Treaty of 1957 are:

Article 2: *… the Community shall … establish uniform standards to protect the health of workers and of the general public and ensure that they are applied*;

Article 30: *Basic safety standards (BSS) shall be laid down within the Community for the protection of the health of workers and the general public against dangers arising from ionising radiations:*

» *maximum permissible doses compatible with adequate safety*
» *maximum permissible levels of exposure and contamination*
» *fundamental principles governing the health surveillance of workers*

Article 31: *The basic standards shall be worked out by the Commission after it has obtained the opinion of a group of persons appointed by the Scientific and Technical Committee from among scientific experts, and in particular public health experts, in the Member States. The Commission shall obtain the opinion of the Economic and Social Committee on these basic standards.*

The last BSS (96/29/Euratom: http://ec.europa.eu/energy/nuclear/radioprotection/doc/legislation/9629_en.pdf) was revised in 2013 with the European Commission adopting Council Directive 2013/59/EURATOM which lays down the basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealed Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom. This Directive is focused on 'environment' with respect to human health protection with the scope stating:

'*This Directive applies to any planned, existing or emergency exposure situation which involves a risk from exposure to ionising radiation which cannot be disregarded from a radiation protection point of view or with regard to the environment in view of long-term human health protection.*'

Within the Directive, the definitions of planned and emergency exposure situations both make reference to the potential for an effect on the environment however these definitions do not place any requirements for considering environmental protection from ionising radiation releases.

The Directive does recognise that contamination of the environment may pose a threat to human health. The Directive goes on to recognise that the Community's secondary legislation so far has regarded such contamination only as a pathway of exposure to members of the public directly affected by radioactive effluent discharged to the environment. While the state of the environment can impact long-term human health, this calls for a policy protecting the environment against the harmful effects of ionising radiation. For the purpose of long-term human health protection, environmental criteria based on internationally recognised scientific

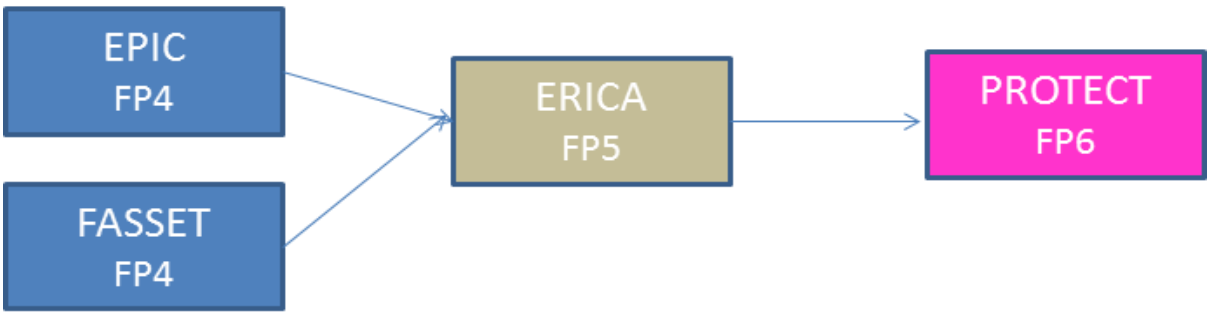
data (such as published by EC, ICRP, United Nations Scientific Committee on the Effects of Atomic Radiation, International Atomic Energy Agency (IAEA)) should be taken into account.

There is therefore no explicit requirement for consideration for the protection of the environment in its own right unlike the International Basic Safety Standards (2014).

Other EC drivers are relevant to current legislation in the UK on this issue (*sorry non UK people but this is a UK funded course!).* Firstly, the European Habitats and Birds Directives on the conservation of natural habitats and of wild flora and fauna. As an example, in the UK, these directives have been implemented through the Conservation of Habitats and Species Regulations 2017. These regulations consolidate all the recent changes in the law to implement the Habitats Directive in the UK. It requires steps to maintain and restore to favourable conservation status habitats and species of Community level interest.

European Assessment approaches

The EC has funded a series of projects to develop an approach to assessment of the effect of radiation exposure on the environment; the relationship between the different projects is shown in the diagram.



The ERICA Integrated Approach uses Reference Organisms in a way which is complementary to that of the Reference Animals and Plants outlined by ICRP. The ERICA project developed the ERICA Tool which is freely available and is the focus of the courses given under this NERC programme. Other tools are also available, notably the freely available RESRAD Biota developed in the USA, there are links to information about the tools on the wiki. www.ceh.ac.uk/PROTECT

Key European publications and information on projects

EC 2014 Council Directive 2013/59/EURATOM which lays down the basic safety standards for protection against the dangers arising from exposure to ionising radiation. EC:

Luxembourg. https://ec.europa.eu/energy/sites/ener/files/documents/CELEX-32013L0059-EN-TXT.pdf

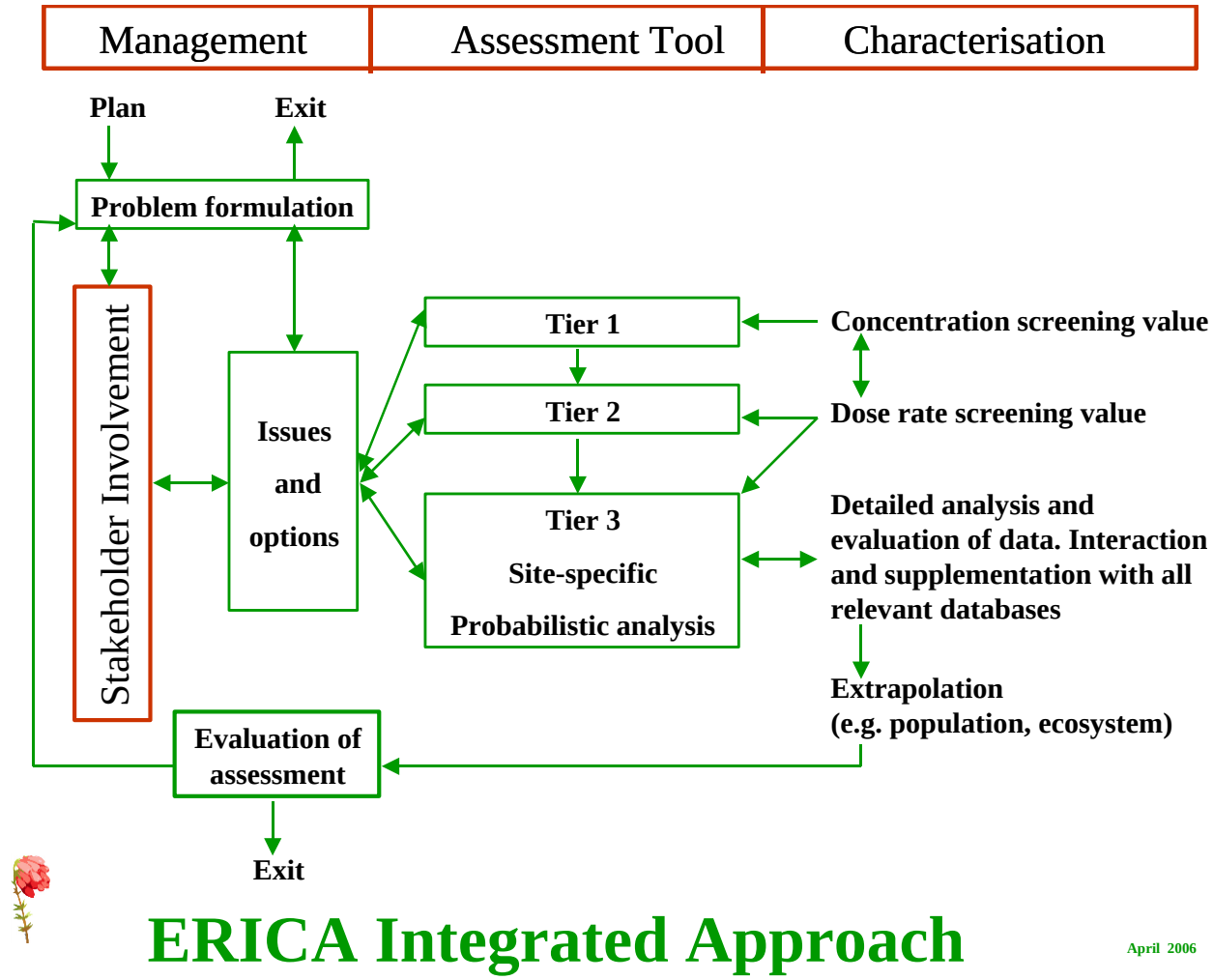
Link to European project outputs:

https://wiki.ceh.ac.uk/display/rpemain/EC+EURATOM+projects

Tiered assessments

Many approaches use a tiered assessment structure (in common with other areas of risk assessments). The approach starts with a simple initial screening through to more refined assessments where needed. It is sometimes referred to as a staged or graded approach. The aim is to ensure that the level of detail in a risk assessment is proportionate with the nature and complexity of the risk being addressed and consistent with decision-making needs.

In the first screening tier the approach is highly conservative (typically with maximum values being used for contamination, transfer rates and so on) and is intended to ensure that if an assessed site passes the first tier there is a very high likelihood that no effect of the radiation present will occur on the ecosystems wildlife populations. As an assessor goes up the tiers the degree of conservatism goes down and the data requirements and resources needed to complete the assessment increase. An example of a tiered approach for ERICA is given below which shows how the tiered approach interacts with other elements of an assessment.



Approach for other chemicals

Both the ICRP and ERICA/PROTECT approaches used emphasise the importance of being consistent with the approach used for other chemicals such as pesticides and heavy metals. There are similarities and differences between chemical and radiological risk assessment approaches. Assessment of chemicals only considers internal exposure whereas that for radiation also considers external exposure, also, the dose from many radionuclides can be combined whereas chemical assessment considers each chemical separately. Currently, chemical assessment often takes account of environmental bioavailability whereas many radiological assessments do not. See https://wiki.ceh.ac.uk/display/rpemain/EC+EURATOM+projects for further information.