NDAWG
National Dose Assessment Working Group

NDAWG GUIDANCE NOTE 2

Guidance on initial/simple assessment tools

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1 Introduction

The Environment Agency, Scottish Environment Protection Agency and the Department of Environment in Northern Ireland in collaboration with the Food Standards Agency and National Radiological Protection Board (now Health Protection Agency) have developed and published principles and guidance for the prospective assessment of public doses [Ref 1].

A staged approach to the assessment of critical group doses for authorisation purposes is recommended. The first stage consists of a simple and cautious assessment of the critical group dose rate (initial radiological assessment). If the resulting dose is less than 0.02 mSv/y then no further assessment would be warranted for the purpose of authorising the discharge of radioactive waste to the environment. Further investigation using more realistic data should be undertaken when the dose exceeds 0.02 mSv/y, in particular if a regulatory decision is dependent on the outcome of the assessment.

A simple staged approach may also be adopted for retrospective assessments [Ref 2]. An initial assessment first, followed by a more detailed assessment, if the dose exceeds 0.02 mSv/y.

This NDAWG guidance note provides guidance on the selection of initial or simple radiological assessment tools which may be used for the initial radiological assessment. Supporting information to this guidance note may be found in an NDAWG meeting paper [Ref 3].

2 Simple assessment tools

2.1 Prospective assessments

These simple assessment tools are available for prospective assessments:

- Environment Agency's initial radiological assessment methodology [Refs 4, 5]. Available as 'pdf' files from the Environment Agency's publication web site.
- National Radiological Protection Board (now HPA) radiological assessments for small users (NRPB-W63) [Ref 6]. Available as a printed report and as a 'pdf' file from the HPA web site.
- National Radiological Protection Board (now HPA) Generalised Derived Constraints [Refs 10, 11].
- International Atomic Energy Agency (IAEA) Safety Reports Series No 19 Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment [Ref 12].

This guidance note considers the use of the first three assessment tools. The IAEA Safety Report describes relatively simple models and methods that can be used to assess the radiological impact of radioactive discharges to the environment. The models and data in this IAEA report are intended for use as screening tools and contain cautious assumptions. It is possible to implement the models using a calculator or by setting up simple spreadsheets and such an approach could be used instead of the other simple tools described in this guidance document.

Information on the scope of the prospective assessment tools and their limitations is provided in Appendix 1.

2.2 Retrospective assessments

One simple assessment tool is available for retrospective assessments:

- National Radiological Protection Board (now HPA) Generalised Derived Limits [Refs 7, 8, 9].

3 Guidance on when to use assessment tools

3.1 Prospective assessments

The prospective dose assessment principles [Ref 1] provides guidance on assessing prospective doses to members of the public. It recommends a cautious initial assessment which should then be followed by a more detailed site specific assessment if the dose exceeds 0.02 mSv/y. The assessment tools may be used in the following way to be consistent with this framework (see Figure 1). Please note that it is not necessary to follow through each step in turn; it may be more appropriate to start at a later step.

- ***Step 1 – Check limits against NRPB Generalised derived constraints***:

  Radionuclide discharge limits may be compared to the appropriate GDCs, where these are available. The GDCs are based on the dose constraint of 0.3 mSv/y. There is no need to undertake a more detailed site specific prospective assessment, if the discharge limits are a small fraction of the GDCs.

  The prospective dose assessment principles state that a more detailed site specific assessment should be undertaken, if the total dose for all radionuclides is greater than 0.02 mSv/y. To ensure that the GDCs are used in a way which is consistent with these principles, the total dose from the different radionuclide discharge limits should be compared to the dose threshold of 0.02 mSv/y.

  Hence, the ratio of each radionuclide discharge limit to the appropriate GDC should be calculated and summed for all radionuclides released via a particular discharge route (e.g. air, sewer). These summed ratios for a particular discharge route should be totalled, unless it is clear that one population group cannot be exposed to discharges from different discharge routes. A detailed site specific assessment should be considered, if the summed ratio(s) exceeds 0.07 (i.e. 0.02 mSv/y divided by 0.3 mSv/y).

  There is no need to proceed further, if no detailed site specific assessment is required. Otherwise, proceed to step 2a.

- ***Step 2a – Initial radiological assessment***:

  Use Environment Agency's initial radiological assessment methodology [Refs 4]. The assessment can be refined to take account of different effective release heights, river flows, estuary/coastal water exchange rates and raw sewage flow rates. Guidance is

also provided on when a more realistic assessment is required. Proceed to step 2b, if a more realistic assessment is required.

- ***Step 2b – More realistic site specific assessment (NRPB-W63)***:

  Use NRPB-W63 to undertake a more realistic site specific assessment, where the initial radiological assessment methodology is not sufficiently flexible to be used. The relevant exposure pathways and site specific data can be selected and used in the assessment. Some data may be sourced from the supporting report to the initial radiological assessment methodology [Ref 5], where it is not available in NRPB-W63.

- ***Step 3 – Detailed site specific assessment using an expert:***

  For complex release routes and exposure pathways, it may be necessary to seek the services of a radiological assessment expert, perhaps from a consulting organisation.

3.2 Retrospective assessments

Generalised derived limits are intended as reference levels against which the results of environmental monitoring can be compared. If a measured environmental concentration exceeds about 10% of the GDL then a more detailed site specific dose assessment may be required. The retrospective dose assessment principles [Ref 2] provides some guidance on retrospective assessments.

4 References

1. Environment Agency, Scottish Environment Protection Agency, Northern Ireland Department of Environment, National Radiological Protection Board and Food Standards Agency (2002). Authorisation of Discharges of Radioactive Waste to the Environment. Principles for the Assessment of Prospective Public Doses. http://publications.environment-agency.gov.uk/pdf/PMHO1202BKLH-e-e.pdf.

2. NDAWG (2005). Assessment of Compliance with the Public Dose Limit: Principles for the Assessment of Total Retrospective Public Doses. NDAWG/2/2005. (http://www.ndawg.org/).

3. NDAWG (2006). Guidance on Simple Dose Assessment Tools. NDAWG Paper 10.04. (http://www.ndawg.org/).

4. Science Report SC030162 Initial Radiological Assessment Methodology – Part 1 User Report ISBN Number 1844325423 April 2006 (http://publications.environment-agency.gov.uk/epages/eapublications.storefront/450967d1001ab534273fc0a802960648/Product/View/SCHO0106BKDT&2DE&2DE).

5. Science Report SC030162 Initial Radiological Assessment Methodology – Part 2 Methods and Input Data ISBN Number 1844325431 April 2006. (http://publications.environment-agency.gov.uk/epages/eapublications.storefront/450967d1001ab534273fc0a802960648/Product/View/SCHO0106BKDV&2DE&2DE).

6. McDonnell C E (2004). Radiological Assessments for Small Users. NRPB W-63.

7. NRPB (1998). Revised generalised derived limits for radioisotopes of strontium, iodine, caesium, plutonium, americium and curium. Doc NRPB, 9(1), 1-34.

8. NRPB (2000). Generalised derived limits for radioisotopes of polonium, lead, radium and uranium. Doc NRPB, 11(2), 43-71.

9. NRPB (2005). Generalised derived limits for radioisotopes of hydrogen, carbon, phosphorus, sulphur, chromium, manganese, cobalt, zinc, selenium, technetium, antimony, thorium and neptunium. Doc NRPB, 16(3), 1-45.

10. Titley, J G, Attwood, C A and Simmonds, J R (2000). Generalised Derived Constraints for Radioisotopes of Strontium, Ruthenium, Iodine, Caesium, Plutonium, Americium and Curium. Doc NRPB, 11(2), 1–41.

11. Harvey, M P and Simmonds, J R (2002). Generalised Derived Constraints for Radioisotopes of Polonium, Lead, Radium and Uranium. Doc NRPB, 13(2), 1–38.

12. IAEA (2001). Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment. Safety Reports Series no 19. International Atomic Energy Agency, Vienna, 2001.

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About NDAWG Guidance Notes

National Dose Assessment Working Group Guidance Notes provide guidance on radiological assessment topics. The UK NDAWG has representatives from Government and its Agencies, nuclear industry, non-nuclear users of radioactive substances, Non-Governmental Organisations and independent experts. The guidance notes are approved by at NDAWG meetings and have been consulted upon for a period of 3 months via the NDAWG website (www.ndawg.org).

Appendix 1 Comparison of scope and limitations of the prospective assessment tools

The different tools which can be used for prospective assessments have been compared in Tables A1.1 – A1.6. The main aspects of the scope and limitations of the prospective assessment tools are as follows:

- ***Environment Agency Initial Radiological Assessment Methodology:***
  - Considers releases to air, river, estuary/coastal waters and sewer.
  - Provides assessment data for 100 radionuclides.
  - Includes a large number of exposure pathways, but does not include sewer maintenance workers.
  - Doses to adults, children, infants and offspring (fetus) are included in the assessment.
  - User is required to make some calculations, multiplying radionuclide limits by dose per unit release data and scaling the result for different effective release heights, river flow rates etc.

- ***Radiological assessment for small users (NRPB-W63):***
  - Considers releases to air, river, estuary/coastal waters and sewer.
  - Provides an assessment methodology for the key radionuclides which will be important for non-nuclear users.
  - Methodology includes all major exposure pathways, except for external radiation from deposited radionuclides which have been released to air. However, data is limited for some radionuclides.
  - Methodology is designed for assessing adult doses only, although some indication is given on doses for other age groups.
  - Detailed calculations are required to assess doses, requiring several parameters to be multiplied together for each radionuclide and exposure pathway.

- ***NRPB Generalised derived constraints:***
  - Considers releases to air, river and sewer, but not estuary/coastal waters.
  - GDCs are currently provided for 31 radionuclides, most of which are important for nuclear discharges. Calculations have also been carried out for a further 19 radionuclides, many of which are relevant to non-nuclear users and a report on these results is in preparation.
  - Methodology includes most exposure pathways, but does not include doses to sewer maintenance workers or fishermen exposed to discharges to the coast/estuary.
  - Adults, children and infants are covered by the methodology, but not offspring (fetus), except for the latest set of radionuclides to be published.
  - Calculations may not be required as the radionuclide discharge limits are compared to the GDCs.

The key differences in assumptions in the assessment tools which may affect the results of assessments are as follows:

- ***Releases to air*** – All assessment tools are broadly equivalent for a ground-level release, so long as the same assumptions are selected, in particular the distance to the location of food production. The GDCs cannot be modified for different effective release heights.

- ***Releases to river*** – The initial radiological assessment methodology uses a cautious model for assessing river bed sediment concentrations and hence external dose rates, leading to higher doses. It also tends to use more cautious concentration

factors for assessing transfer of radionuclides to fish. The GDCs and NRPB-W63 use an empirical dispersion and sedimentation model which may give more realistic river bed concentrations. However, there is limited radionuclide data available and the results do not always match observations. For example, the model assumes that radioiodine does not deposit in river bed sediments, but radioiodine has been found in sediments in the River Thames. The GDCs cannot be modified for different river flow rates. Offspring (fetal) doses can become important for phosphorus-32/33 in fish and assessment of these doses is not included in the GDCs and NRPB-W63. Offspring doses have been included in the as yet unpublished GDCs for phosphorus isotopes.

- ***Releases to estuary/coastal waters*** – NRPB-W63 does not take account of radioactive decay for releases to estuary/coastal waters, leading to higher doses than the initial radiological assessment methodology.

- ***Releases to sewer*** - The initial radiological assessment methodology uses a lower occupancy for workers adjacent to sludge tanks than the other methodologies, leading to lower doses. The initial radiological assessment methodology and NRPB-W63 have nearly identical assumptions for disposal of sludge to land, leading to similar doses. The GDCs do not take account of partitioning of radionuclides or radioactive decay during transport and storage of sludge, so generally are more cautious.

References

A1.1. J R Simmonds, G Lawson and A Mayall (1995). Methodology for Assessing the Radiological Consequences of Routine Releases of Radionuclides to the Environment. European Commission, Luxembourg, EUR 15760 EN, Radiation Protection 72.

A1.2. J T Smith & M Bowes (2002). *Aquatic Dispersion Models for Short Duration Radionuclide Releases*. Environment Agency R&D Technical Report P3-074.

Table A1.1 Exposure pathways considered in prospective methodologies

Release route	Exposed population group	Exposure pathway	Initial Rad Asses	NRPB-W63	NRPB GDCs
Air	Local resident family	Inhalation of radionuclides in the effluent plume	✓	✓	✓
		External irradiation from radionuclides in the effluent plume	✓	✓	✓
		External irradiation from radionuclides deposited to the ground	✓	-	✓
		Consumption of terrestrial food incorporating radionuclides deposited to the ground	✓	✓	✓
Estuary or coastal water	Fisherman family	External irradiation from radionuclides deposited in shore sediments	✓	✓	-
		Consumption of seafood incorporating radionuclides	✓	✓	-
River	Angler family	External irradiation from radionuclides deposited in bank sediments	✓	✓	✓
		Consumption of freshwater fish incorporating radionuclides	✓	✓	✓
		Consumption of drinking water containing radionuclides	✓	✓	✓
	Irrigated food consumer family	Consumption of terrestrial food irrigated with river water and incorporating radionuclides	✓	✓	✓

Table A1.1 Continued

Release route	Exposed population group	Exposure pathway	Initial Rad Asses	NRPB-W63	NRPB GDCs
Sewer	Maintenance worker (adults only)	External irradiation from radionuclides in raw sewage and sludge	-	✓	-
		Inadvertent inhalation and ingestion of raw sewage and sludge containing radionuclides	-	✓	-
	Sewage treatment workers (adults only)	External irradiation from radionuclides in raw sewage and sludge	✓	✓	✓
		Inadvertent inhalation and ingestion of raw sewage and sludge containing radionuclides	✓	✓	✓
	Farming family living on land conditioned with sewage sludge	Consumption of food produced on land conditioned with sludge and incorporating radionuclides	✓	✓	✓
		External irradiation from radionuclides in sludge conditioned soil	✓	✓	✓
		Inadvertent inhalation and ingestion of sludge conditioned soil	✓	✓	✓
	Children playing in brook which receives treated effluent from sewage works (children only)	External irradiation from radionuclides deposited in bank sediments	✓	✓ models can be adapted	-
		Inadvertent consumption of water and sediment containing radionuclides	✓	✓ models can be adapted	-
	Angler family (river receives treated effluent from sewage works)	External irradiation from radionuclides deposited in bank sediments	✓	✓	✓
		Consumption of freshwater fish incorporating radionuclides	✓	✓	✓
		Consumption of water containing radionuclides	✓	✓	✓
	Irrigated food consumer family (river receives treated effluent from sewage works)	Consumption of terrestrial food irrigated with river water and incorporating radionuclides	✓	✓	✓
	Fisherman family (estuary/coastal water receives treated effluent from sewage works, typically via a river)	External irradiation from radionuclides deposited in sediments	✓	✓	-
		Consumption of fish incorporating radionuclides	✓	✓	-

Table A1.2 Comparison of prospective methodologies

Aspect of methodology	Environment Agency Initial Radiological Assessment	NRPB-W63	NRPB GDCs
Radionuclides	100 radionuclides	Up to 37 radionuclides – these are important for non-nuclear users. Methodology can be extended for other radionuclides if data is sourced from elsewhere	31 – Currently only cover a few important radionuclides for non-nuclear users
Release routes	Releases to air, river, coast/estuary and sewer.	Releases to air, river, coast/estuary and sewer.	Releases to air, river and sewer.
Exposed population groups and exposure pathways	See Table A1.1. Sewer maintenance workers are not included.	See Table A1.1. External radiation from deposited activity from release to air is not included.	See Table A1.1. Fishermen exposed to discharges into the coast/estuary; sewer maintenance worker; and children playing in a brook flowing from sewage treatment works are not included.
Age groups	Adults, children, infants and offspring (fetus).	Adults. Some indication of doses for other age groups given.	Adults, children and infants.

Table A1.3 Releases to air – key assumption comparison

Assessment parameter	Environment Agency Initial Radiological Assessment	NRPB-W63	NRPB GDCs
Effective release height	Default of ground-level, but can be scaled by effective release heights up to 80 m.	10 m in example assessment. Data for release heights ground-level to 40 m.	1 m
Dispersion model	Gaussian plume 50%D	Gaussian plume, assuming 60%D in example assessment. Data for range of other weather conditions.	Gaussian plume 50%D
Location of group exposed to inhalation and external radiation doses	100 m	100 m in example assessment. Data available for distances from 100m – 10 km.	100 m
Location of food production	500 m	500 m for vegetables and 1 km for meat and milk in example assessment. Data available for distances from 100m – 10 km.	500 m
Foods included	Milk, cow meat, cow offal, sheep meat, sheep offal, green vegetables, root vegetables and fruit.	Milk, beef meat, sheep meat, green vegetables and root vegetables.	Milk, milk products, cow meat, cow offal, sheep meat, sheep offal, green vegetables, root vegetables and fruit.

Table A1.4 Releases to river – key assumption comparison

Assessment parameter	Environment Agency Initial Radiological Assessment	NRPB-W63	NRPB GDCs
River flow rate	Default of 1 m^3/s., but can be scaled for different flow rates.	10 m^3/s for fish and irrigation water exposure pathways and 20 m^3/s for drinking water in example assessment. Doses can be scaled for different flow rates.	1 m^3/s.
Dispersion modelling	Simple dilution model, taking account of loss of activity to particulate phase. Bed sediment concentrations calculated using sediment distribution coefficients.	PC Cream compartment model. Water concentration data is similar to simple dilution model, but empirical model used for bed sediment concentrations.	PC Cream compartment model. Water concentration data is similar to simple dilution model, but empirical model used for bed sediment concentrations.
Transfer to fish	More cautious since derived from a number of sources [e.g. Ref A1.1, A1.2]	Derived from EU report [Ref A1.1]	Derived from EU report [Ref A1.1]
Freshwater fish consumption	20 kg/y adults	20 kg/y adults	20 kg/y adults
Occupancy over sediment	1000 h/y adults	1000 h/y adults	500 h/y adults

Table A1.5 Releases to coast / estuary – key assumption comparison

Assessment parameter	Environment Agency Initial Radiological Assessment	NRPB-W63	NRPB GDCs
Exchange rate	Default of 100 m^3/s (30 m^3/s for small estuaries, particularly on East coast of Britain), but can be scaled for different flow rates.	630 m^3/s in example assessment. Doses can be scaled for different exchange rates.	Not included.
Dispersion modelling	PC Cream Doris.	Simple dilution model.	Not included.
Shellfish included	Fish, crustacea, mollusc.	Fish, crustacea, mollusc.	Not included.
Fish consumption	Adults 50 kg/y local box Adults 50 kg/y regional box	Adults 100 kg/y	Not included.
Crustacea consumption	Adult 20 kg/y	Adult 20 kg/y	Not included.
Mollusc consumption	Adult 20 kg/y	Adult 20 kg/y	Not included.
Occupancy	Adult 2000h/y	Adult 2000h/y	Not included.

Table A1.6 Releases to sewer – key assumption comparison

Assessment parameter	Environment Agency Initial Radiological Assessment	NRPB-W63	NRPB GDCs
Raw sewage flow rate	Default of 60 m^3/day, but can be scaled.	43200 m^3/day in example assessment. Doses can be scaled for different flow rates.	60 m^3/day. Scaling methodology is provided.
Partitioning between sewage sludge and treated effluent	Included	Included	Worst case assumption that either 100% to sludge or 100% to treated effluent.
% solids in raw sewage	0.05%	0.05%	0.05%
% solids in treated sludge	5%	5%	5%
Occupancy at sewage treatment works	500 h/y next to sludge tanks and 1500 h/y next to raw sewage tanks	2000 h/y in sewage treatment works	1000 h/y next to sludge tanks for external dose and 2000 h/y in sewage works for inadvertent ingestion and inhalation dose
Sludge spreading rate	8 kg/m^2/y	8 kg/m^2/y	8 kg/m^2/y
Foods included	Milk, cow meat, cow offal, sheep meat, sheep offal, green vegetables and root vegetables.	Milk, milk products, cow meat, cow offal, sheep meat and sheep offal.	Milk, cow meat, cow offal, sheep meat and sheep offal.

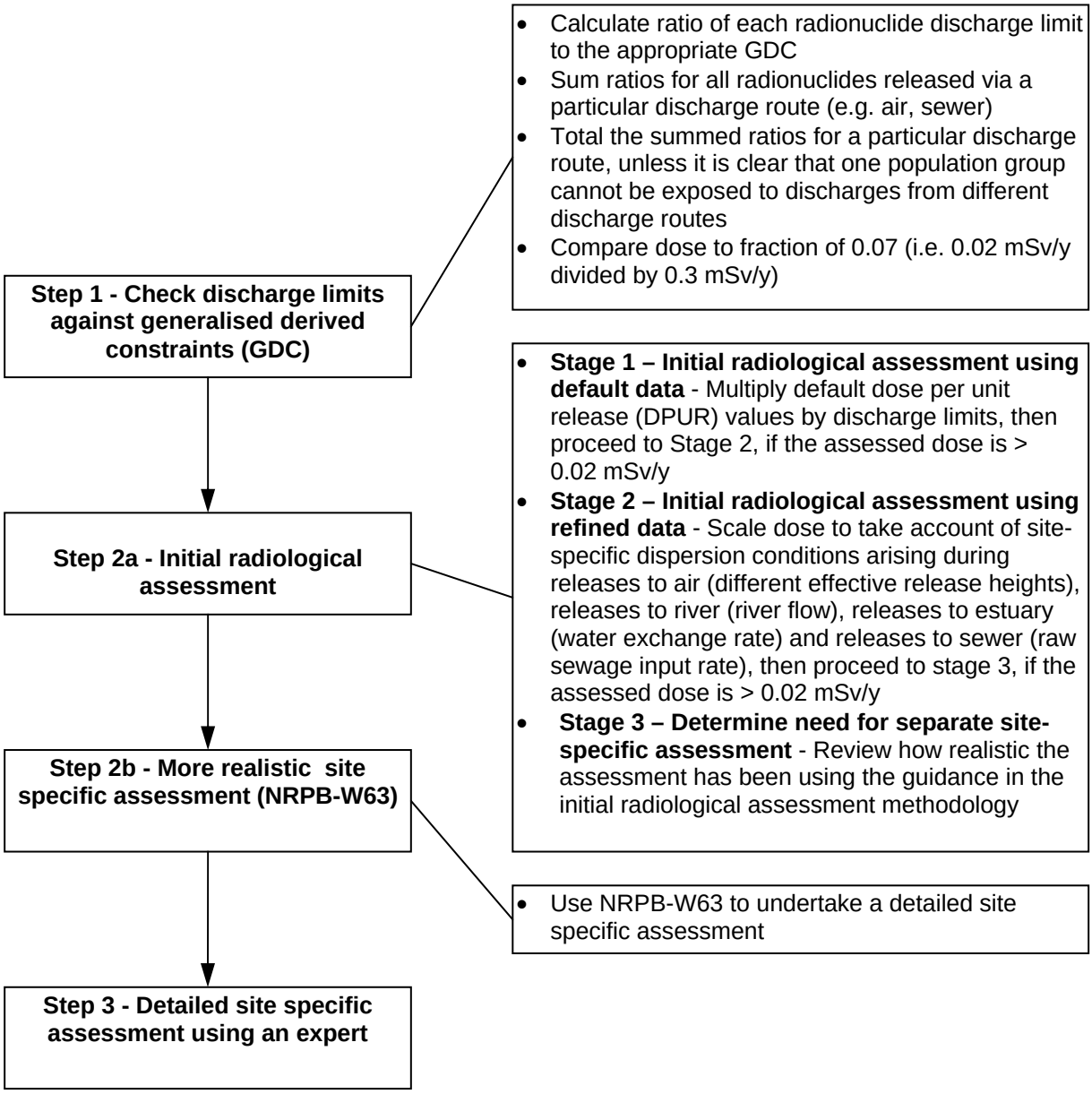

Figure 1 When to use initial/simple prospective assessment tools

Glossary

Absorbed Dose	Is the ionising radiation energy absorbed in a material per unit mass. The unit for absorbed dose is the gray (Gy) which is equivalent to J/kg.
Committed Effective Dose	The sum of the committed equivalent doses for all organs and tissues in the body resulting from an intake (of a radionuclide), having been weighted by their tissue weighting factors. The unit of committed effective dose is the sievert (Sv).
Committed Equivalent Dose	Is the integral of the absorbed dose-rate over time for a tissue or organ, weighted for the type and quality of the radiation by a radiation weighting factor. For adults and children the default time integration period is 50 years and 70 years respectively. The unit of committed equivalent dose is the sievert (Sv).
Dose	Dose is used as convenient short-hand for either effective dose, committed effective dose or a total including both.
Effective dose	The sum of the equivalent doses from internal and external radiation in all tissue and organs of the body, having been weighted by their tissue weighting factors. The unit of effective dose is the sievert (Sv).
Equivalent Dose	Is the absorbed dose in a tissue or organ, weighted for the type and quality of the radiation by a radiation weighting factor. The unit of equivalent dose is the sievert (Sv).
Prospective assessment	Estimation of the doses that may be received by a critical group from future sources of radiation.
Retrospective assessment	Calculation of doses that have actually been received by a critical group.