MONITORING OF RADIOACTIVITY IN THE ENVIRONMENT

Asian Nuclear Safety Network (ANSN)
Regional Workshop on Radiological Environmental Impact Assessment for Nuclear Installations
Hosted by the Government of the Philippines through the Philippine Nuclear Research Institute (PNRI)
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2. Prospective and retrospective dose assessment
3. UK examples

Purposes of monitoring

Monitoring carried out by operator

- Confirms activities in environmental media are consistent with measured and reported discharges (no fugitive emissions)
- Allows retrospective dose assessments to be performed to confirm results from prospective assessment

Independent monitoring carried out by regulators

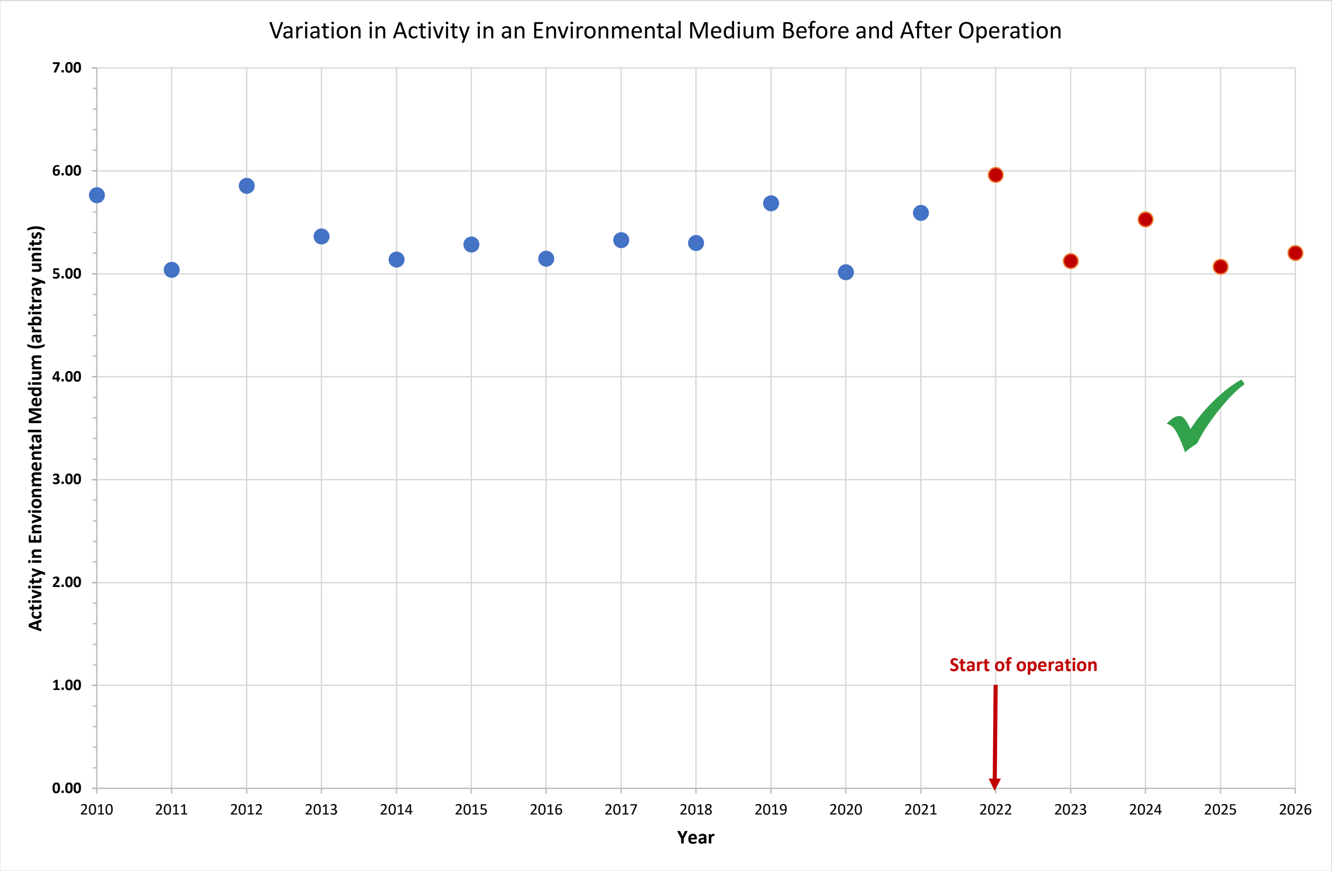
- Check on result reported by operator
- Allows retrospective dose assessments to be performed to confirm doses from all sources are below regulatory limits.

Monitoring

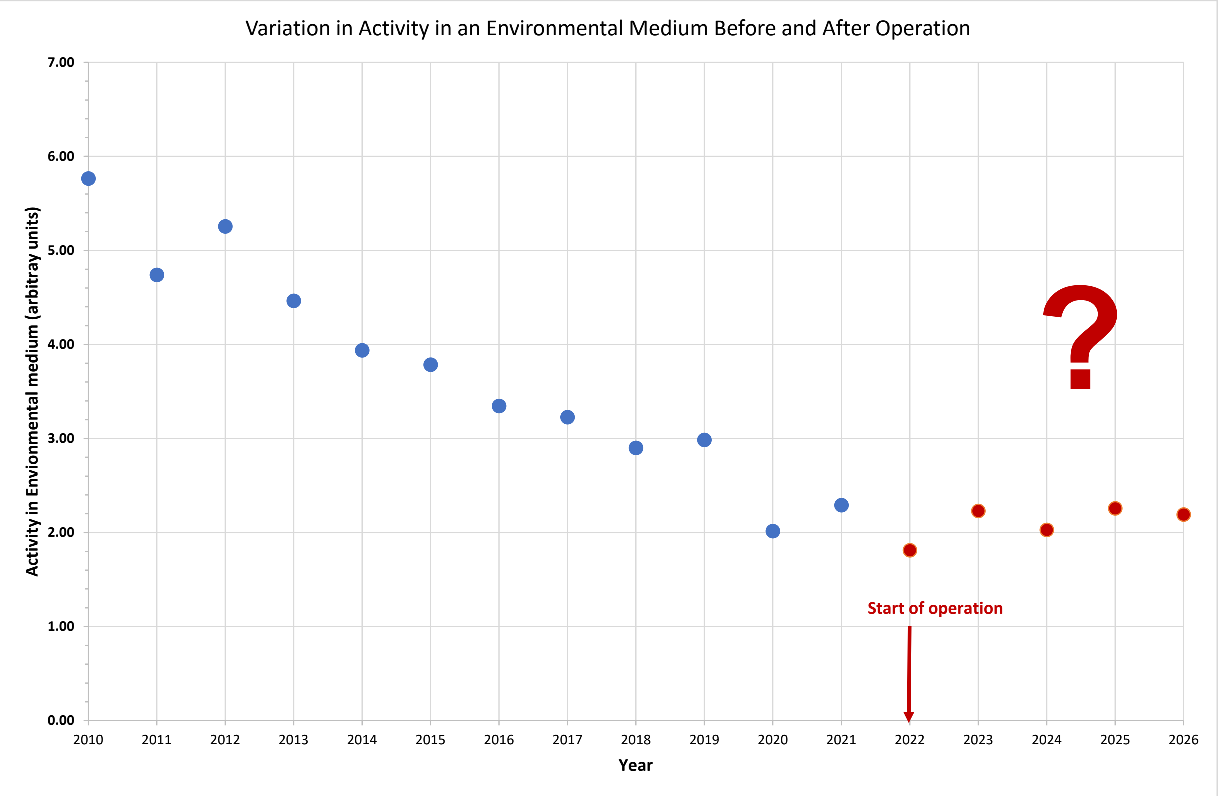
Monitoring should begin before operation to establish the background or baseline

- So that the difference from operating the installation can be determined
- Several years of data are needed so that any trends can be identified

Environmental baseline - trends



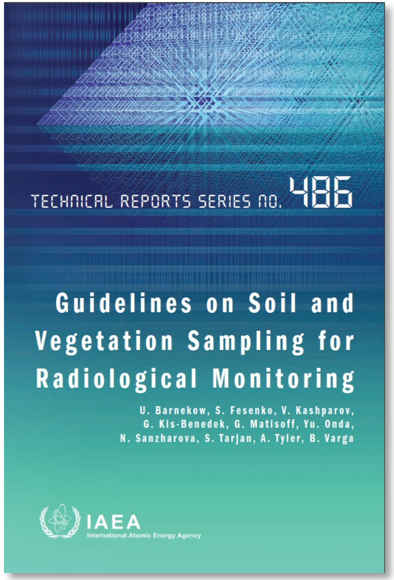
Environmental baseline - trends



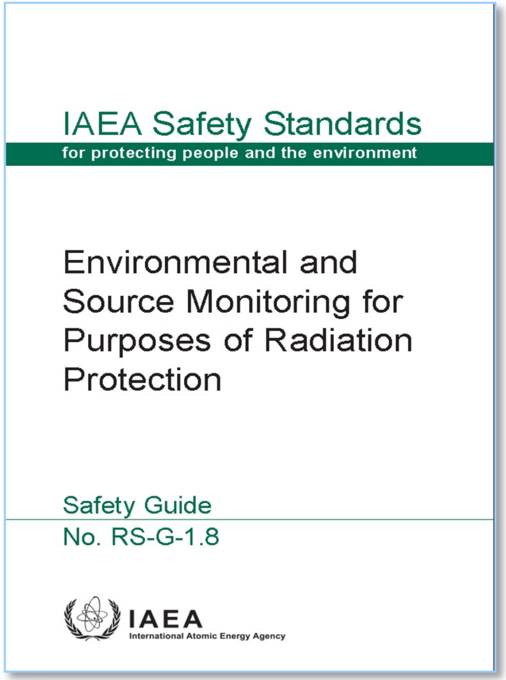
Monitoring

Monitoring should begin before operation to establish the background or baseline

- So that the difference from operating the installation can be determined
- Several years of data are needed so that any trends can be identified
- Dispersion modelling using data from site characterization should determine locations and media where monitoring during operation are likely to be carried e.g.
    - Air concentration where people live
    - Location of maximum ground deposition from atmospheric discharges from stack
    - Activities in water and sediments close to liquid discharge outfalls
    - Activities in groundwater
    - Activities in food produced locally



Environmental monitoring – retrospective dose assessment



Guidance for environmental and source monitoring programmes is provided in Environmental and Source Monitoring for Purposes of Radiation Protection, IAEA Safety Standards Series No. RS-G-1.8

1.2. The uncontrolled release of radionuclides to the atmospheric, aquatic and terrestrial environments may occur as a result of a nuclear or radiological accident. Monitoring of the accidental release at its source, and especially the direct monitoring of the environmental contamination with radionuclides, is necessary for the assessment and execution of actions for public protection and longer term countermeasures as well as of emergency occupational radiation protection. In such cases individual monitoring may be justified. In areas historically contaminated with long lived radionuclides, monitoring is essential for the protection of the public and as a basis for restoration activities.

Dose assessment - recap

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Discharges to environment (air and liquid)

Dispersion and transfer of radionuclides in atmosphere and aquatic environment

Concentrations of radionuclides in environmental media and food

Exposure of public

- Identify representative person (location, habit data)
- Calculate dose for each pathway (food consumption, inhalation, external radiation from deposited activity etc...)
- Sum dose over all pathways

Compare dose with Limits and Constraints

Dose assessment – Prospective assessment

Use Discharge Limits in Permit

Can use models (eg PC-CREAM) or more simple methods if appropriate (see IAEA SRS-19)

Calculate environmental concentrations

Discharges to environment (air and liquid)

Dispersion and transfer of radionuclides in atmosphere and aquatic environment

Concentrations of radionuclides in environmental media and food

Exposure of public

Identify representative person (location, habit data)

Calculate dose for each pathway (food consumption, inhalation, external radiation from deposited activity etc....)

Sum dose over all pathways

Compare dose with Limits and Constraints

Demonstrate that discharges at permitted limits would give a dose to the Representative Person below dose limits/constraints and therefore public protected

Habit data – e.g. food consumption data will be different

Identify Representative and exposure pathways and calculate dose

Dose assessment – Retrospective assessment

Use measured environmental concentrations - may include activity from other sources

Discharges to environment (air and liquid)

Dispersion and transfer of radionuclides in atmosphere and aquatic environment

Concentrations of radionuclides in environmental media and food

Exposure of public

Identify representative person (location, habit data)

Calculate dose for each pathway (food consumption, inhalation, external radiation from deposited activity etc...)

Sum dose over all pathways

Compare dose with Limits and Constraints

Demonstrate that actual discharges during the year gave a dose to the Representative Person below dose limits/constraints and therefore public protected

Identify Representative Person and exposure pathways and calculate dose

Environmental Monitoring – UK Example
Radioactivity in the Food and the Environment (RIFE)

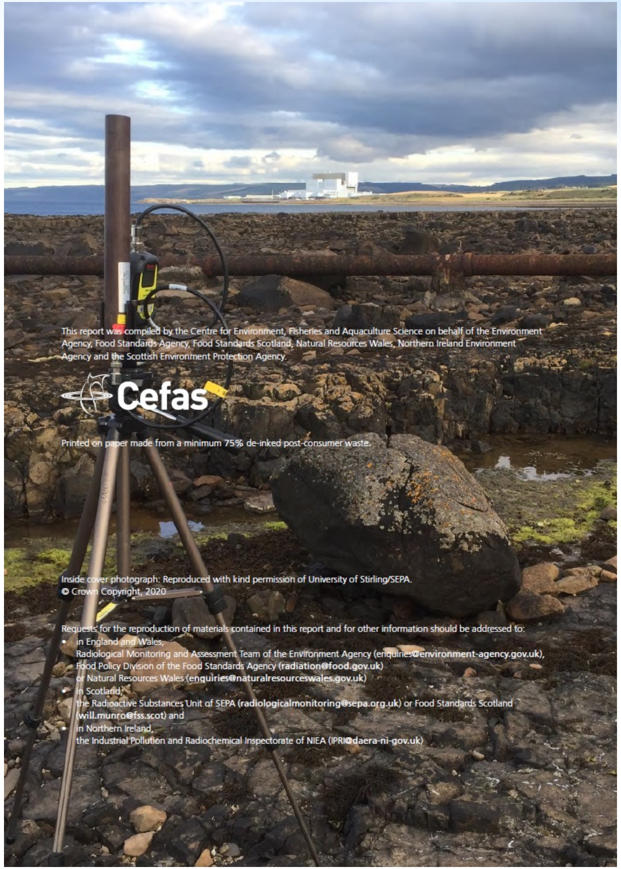
RIFE provides a detailed assessment of radioactivity in food and the environment in the UK and the public's exposure to radiation

Monitoring is carried out around all nuclear licensed sites - additional to and independent of site operators' programmes

Additional monitoring may be carried out following incidents at licensed sites in the UK or to assess the impact on the UK population of incidents elsewhere such as Fukushima and Chernobyl

Monitoring in the Channel island for discharges from Cap La Hague reprocessing plant in France

RIFE Reports

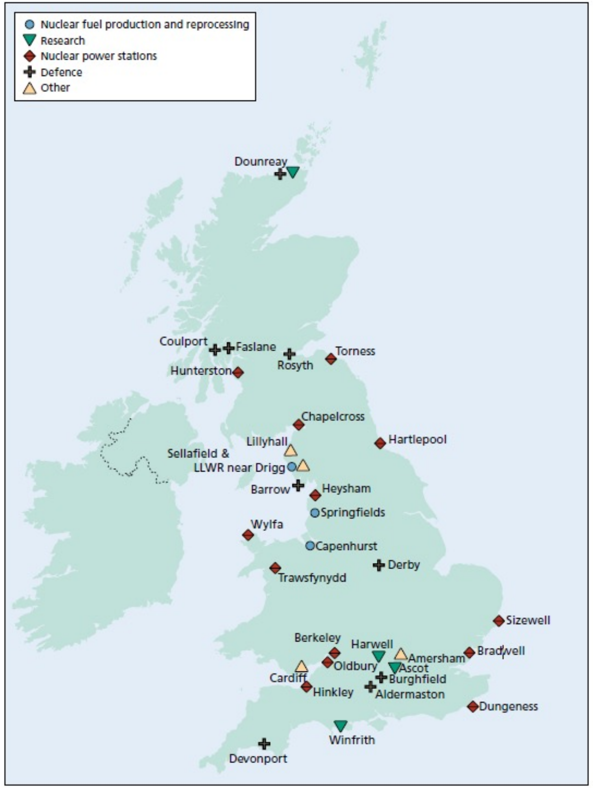


https://www.gov.uk/government/publications/radioactivity-in-food-and-the-environment-rife-reports

https://www.food.gov.uk/research/radioactivity-in-food-and-the-environment

Environmental Monitoring – Summary of Doses to Public from RIFE-25 (2019)

Figure 1.4. Principal nuclear site sources of radioactive waste disposal in the UK, 2019 (Showing main initial operation. Some operations are undergoing decommissioning)



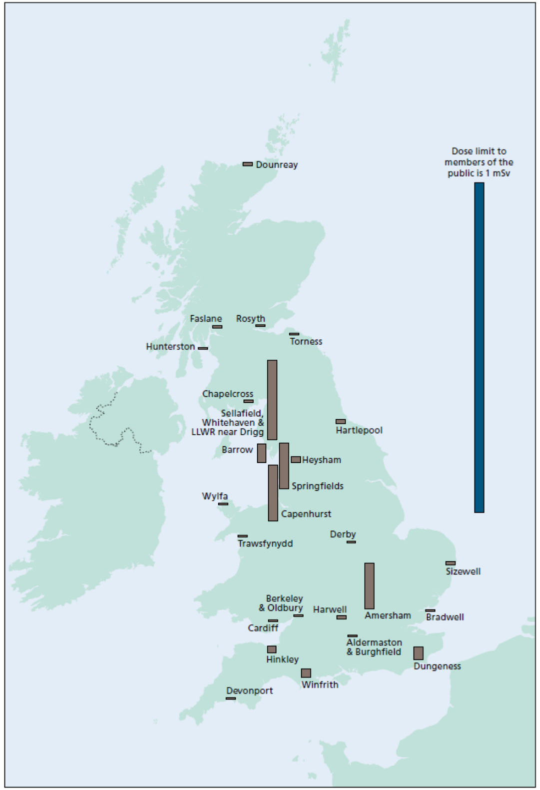


Figure S1. *Total doses* in the UK due to radioactive waste discharges and direct radiation, 2019 (Exposures at Sellafield, Whitehaven and Drigg receive a significant contribution to the dose from technologically enhanced naturally occurring radionuclides from previous non-nuclear industrial operations)

Environmental Monitoring – Summary of Doses to Public from RIFE-25 (2019)

Summary Table S *Total doses* due to all sources at major UK sites, 2019[a]

Establishment	Exposure, mSv[b] per year	Contributors[c]
Nuclear fuel production and processing		
Capenhurst	0.17	Direct radiation
Springfields	0.14	Direct radiation
Sellafield[d]	0.24	Crustaceans, Molluscs, ^{210}Po
Research establishments		
Dounreay	0.010	Green vegetables, potatoes, root vegetables, ^{129}I[e], ^{238}Pu, $^{239+240}$Pu, ^{241}Am
Harwell	0.010	Direct radiation
Winfrith	0.027	Direct radiation
Nuclear power stations		
Berkeley and Oldbury	<0.005	Direct radiation
Bradwell	<0.005	Gamma dose rate over sediment
Chapelcross	0.007	Milk, ^{35}S[e], ^{90}Sr
Dungeness	0.037	Direct radiation
Hartlepool	0.013	Direct radiation, gamma dose rate over sediment
Heysham	0.018	Gamma dose rate over sediment
Hinkley Point	0.021	Gamma dose rate over sediment
Hunterston	<0.005	Direct radiation
Sizewell	0.010	Direct radiation
Torness	<0.005	Direct radiation
Trawsfynydd	0.005	Exposure over sediment
Wylfa	<0.005	Gamma dose rate over sediment
Defence establishment		
Aldermaston and Burghfield	<0.005	Milk, ^{3}H[e], ^{137}Cs[e], ^{234}U, ^{238}U
Barrow	0.057	Gamma dose rate over sediment
Derby	<0.005	Water, ^{60}Co[e]
Devonport	<0.005	Fish, gamma dose rate over sediment, ^{241}Am[e]
Faslane	0.007	Fish, gamma dose rate over sediment, ^{137}Cs, ^{241}Am[e]
Rosyth	<0.005	Direct radiation, gamma dose rate over sediment
Radiochemical production		
Amersham	0.14	Direct radiation
Cardiff	<0.005	Gamma dose rate over sediment
Industrial and landfill		
LLWR near Drigg[d]	0.24	Crustaceans, Molluscs, ^{210}Po
Whitehaven[d]	0.24	Crustaceans, Molluscs, ^{210}Po

[a] *Includes the effects of waste discharges and direct radiation from the site. May also include the far-field effects of discharges of liquid waste from Sellafield*

[b] *Committed effective dose calculated using methodology of ICRP 60 to be compared with the annual dose limit of 1 mSv. Data are presented to 2 significant figures or 3 decimal places. Data below 0.005 mSv are reported as <0.005 mSv*

[c] *Pathways and radionuclides that contribute more than 10% of the total dose. Some radionuclides are reported as being at the limits of detection*

[d] *The doses from man-made and naturally occurring radionuclides were 0.052 and 0.19 mSv, respectively. The source of man-made radionuclides was Sellafield; naturally occurring ones were from the phosphate processing works near Sellafield at Whitehaven. Minor discharges of radionuclides were also made from the LLWR near Drigg site into the same area*

[e] *The assessed contribution is based on data at limits of detection*

Average UK Exposure

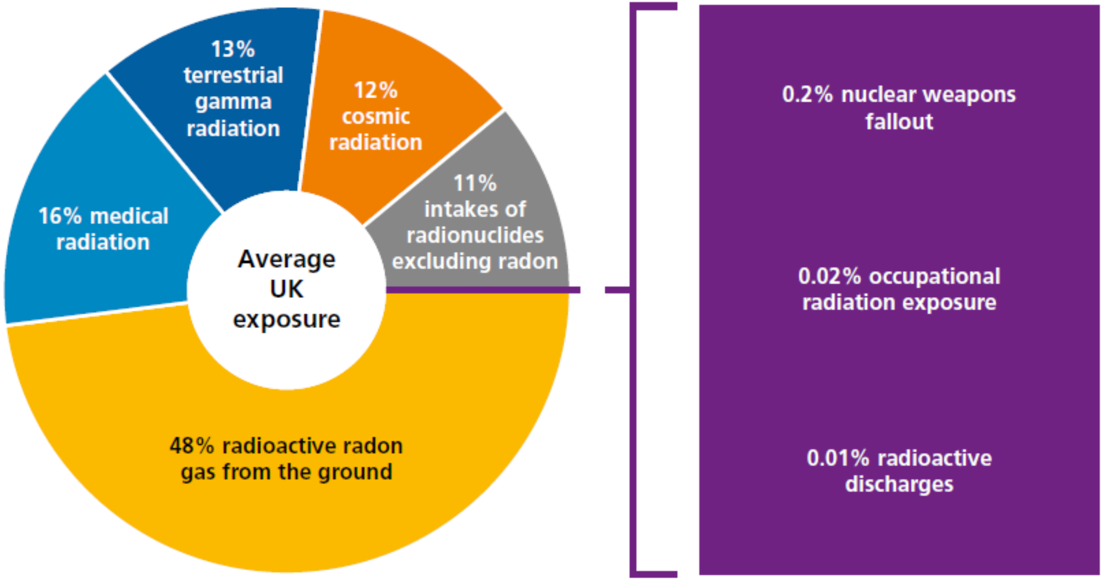


Figure S2. Average UK population exposure from natural and man-made sources of radioactivity (Oatway *et al.*, 2016)

RIFE – Trends in dose around UK nuclear sites (2008-2019)

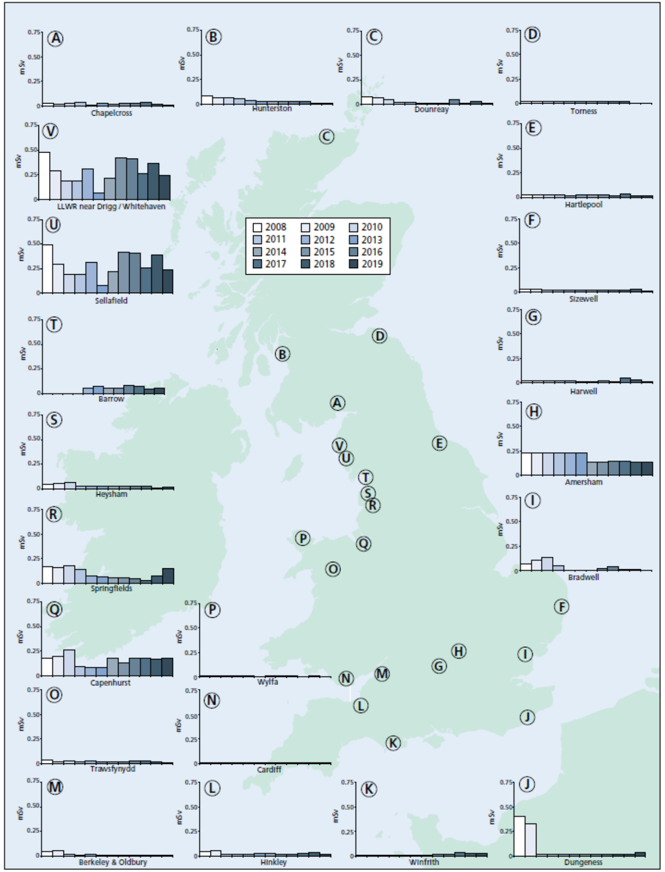


Figure 1.2. *Total doses* around the UK's nuclear sites due to radioactive waste discharges and direct radiation (2008-2019). (Exposures at Sellafield/Whitehaven/LLWR receive a significant contribution to the dose from technologically enhanced naturally occurring radionuclides from previous non-nuclear industrial operations)

Monitoring locations around the Sellafield site

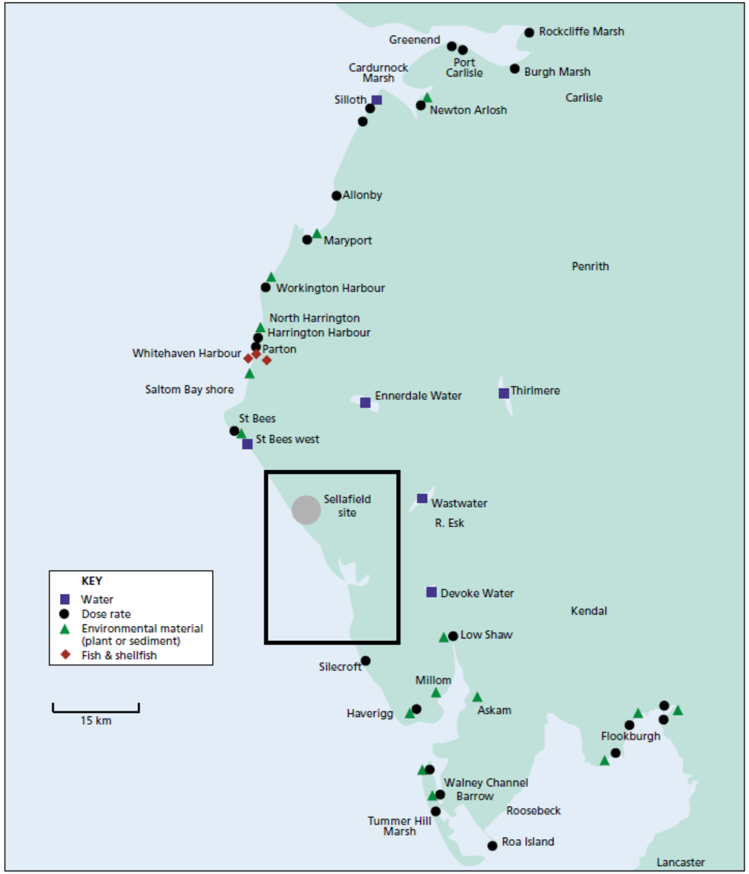


Figure 2.13. Monitoring locations in Cumbria, 2019 (not including farms)

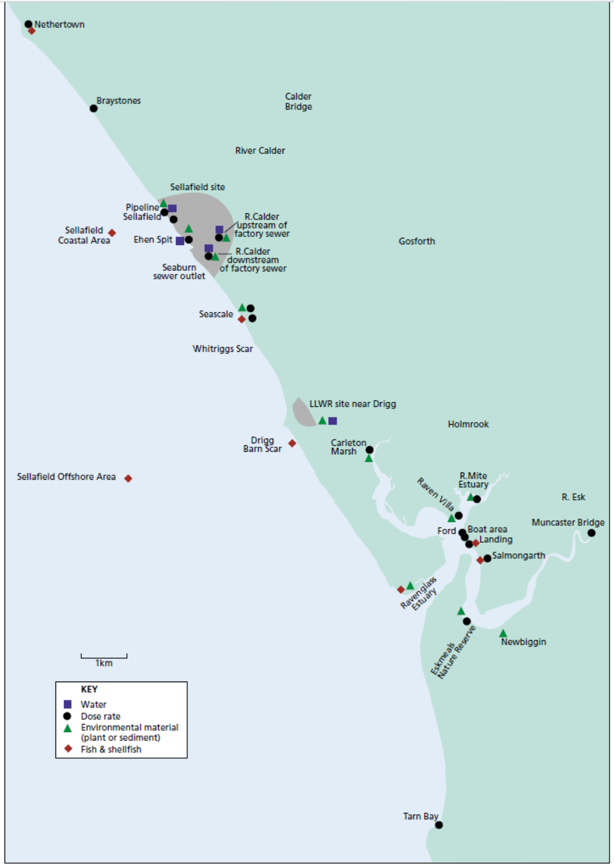


Figure 2.14. Monitoring locations at Sellafield, 2019 (not including farms)

Discharges and Monitoring

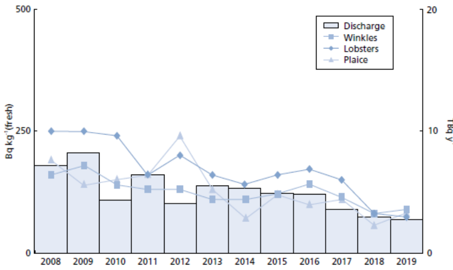


Figure 2.15. Carbon-14 liquid discharge from Sellafield and concentrations in plaice, lobsters and winkles near Sellafield, 2008-2019

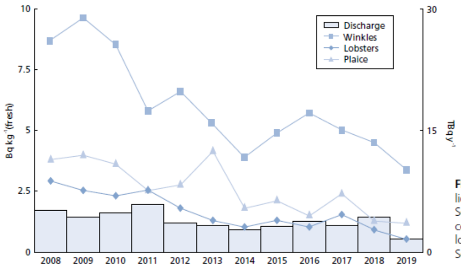


Figure 2.18. Caesium-137 liquid discharge from Sellafield and concentrations in plaice, lobsters and winkles near Sellafield, 2008-2019

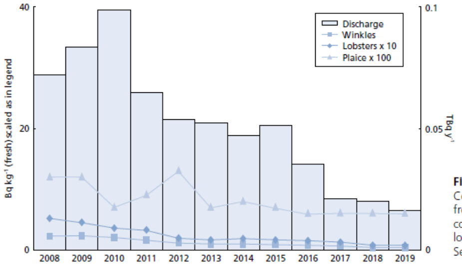


Figure 2.16. Cobalt-60 liquid discharge from Sellafield and concentrations in plaice, lobsters and winkles near Sellafield, 2008-2019

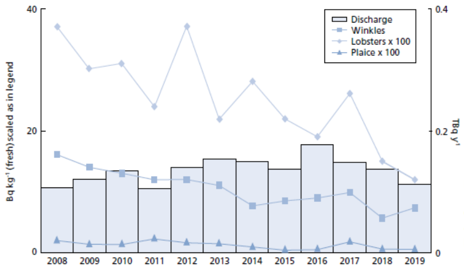


Figure 2.19. Plutonium-239+240 liquid discharge from Sellafield and concentrations in plaice, lobsters and winkles near Sellafield, 2008-2019

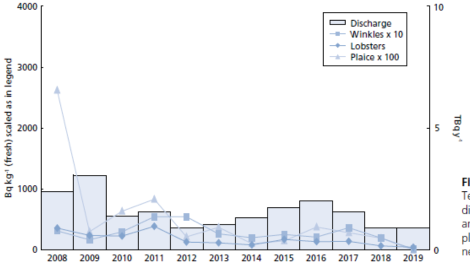


Figure 2.17. Technetium-99 liquid discharge from Sellafield and concentrations in plaice, lobsters and winkles near Sellafield, 2008-2019

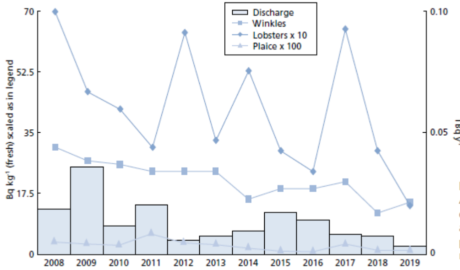


Figure 2.20. Americium-241 liquid discharge from Sellafield and concentrations in plaice, lobsters and winkles near Sellafield, 2008-2019

Discharges and Monitoring

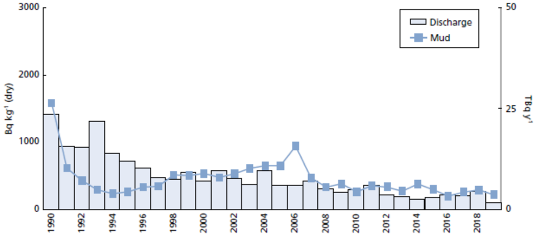


Figure 2.21. Caesium-137 liquid discharge from Sellafield and concentration in mud at Ravenglass, 1990-2019

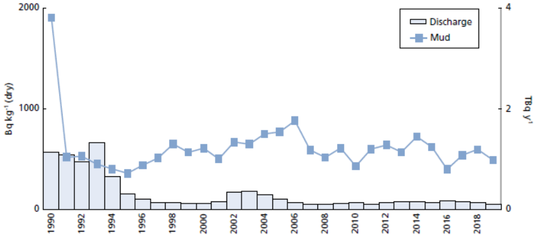


Figure 2.22. Plutonium-alpha liquid discharge from Sellafield and plutonium-239+240 concentration in mud at Ravenglass, 1990-2019

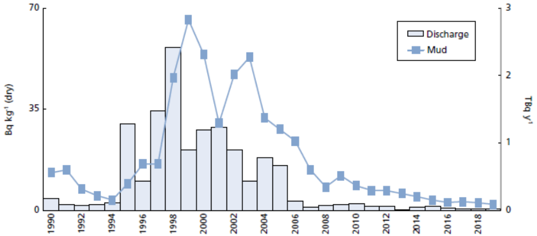


Figure 2.23. Cobalt-60 liquid discharge from Sellafield and concentration in mud at Ravenglass, 1990-2019

RIFE – Example results: Cs-137 in marine sediments near NPPs (2003-2012)

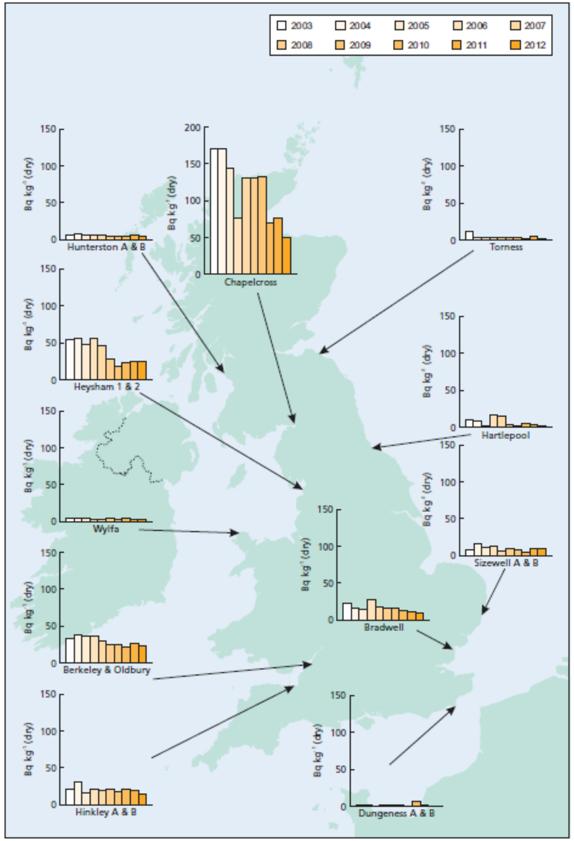


Figure 4.2. Caesium-137 concentration in marine sediments near nuclear power stations between 2003-2012

RIFE – Summary of results for Sizewell

Gaseous discharges and terrestrial monitoring

- Gamma-ray spectrometry and analysis of tritium, carbon-14 and sulphur-35 in milk, crops and fruit generally showed very low concentrations
- Tritium concentrations in local freshwater were all low
- Carbon-14 concentrations were detected in locally produced foods, above background concentrations
- Gross alpha and beta activities in surface waters were less than the WHO screening levels for drinking water

Liquid waste discharges and aquatic monitoring

- Caesium-137 discharges decreased from both Sizewell A and Sizewell B from 2011
- Analysis of seafood, sediment, and seawater, and measurements of gamma dose rates in intertidal areas gave low concentrations of artificial radionuclides mainly due to the distant effects of Sellafield discharges and to weapons testing fallout
- Tritium concentrations in seafood were all below the LoD.

RIFE – results for Sizewell (dose)

'B' station:1200 MWe PWR

'A' station: two Magnox reactors undergoing decommissioning

Dominant contributor is direct radiation (0.020 mSv)

- Much lower than limit (1 mSv) and site constraint (0.5 mSv)

Table 4.1. Individual doses – nuclear power stations, 2012

Site	Exposed population[a]	Exposure, mSv per year					
		Total	Fish and shellfish	Other local food	External radiation from intertidal areas or the shoreline	Gaseous plume related pathways	Direct radiation from site
Sizewell							
Total dose – all sources	**Local adult inhabitants (0-0.25km)**	**0.021**	**<0.005**	**<0.005**	**<0.005**	**<0.005**	**0.020**
Source specific doses	Seafood consumers	<0.005	<0.005	–	<0.005	–	–
	Houseboat occupants	0.010	–	–	0.010	–	–
	Infant inhabitants and consumers of locally grown food	<0.005	–	<0.005	–	<0.005	–

RIFE – results for Sizewell (radioactivity in environmental samples)

Table 4.8(a). Concentrations of radionuclides in food and the environment near Sizewell nuclear power stations, 2012

Material	Location	No. of sampling observations	Mean radioactivity concentration (fresh)[a], Bq kg^{-1}				
			^{3}H	^{14}C	^{137}Cs	^{238}Pu	$^{239}Pu + ^{240}Pu$
Marine samples							
Cod	Sizewell	2	<25		0.21		
Sole	Sizewell	2	<25		<0.08		
Crabs	Sizewell	2		38	0.09	0.000053	0.00063
Lobsters	Sizewell	1			0.14	0.000044	0.00037
Pacific oysters	Butley Creek	1			0.04		
Pacific oysters	Blyth Estuary	1			0.07		
Mussels	River Alde	2	<30		<0.09		
Sediment	Rifle range	2[E]			<0.44		
Sediment	Aldeburgh	2[E]			<0.44		
Sediment	Southwold	2[E]			8.6		
Seawater	Sizewell	2[E]	<3.7		<0.21		

RIFE – results for Sizewell (radioactivity in environmental samples) continued

Table 4.8(a). Concentrations of radionuclides in food and the environment near Sizewell nuclear power stations, 2012

Material	Location	No. of sampling observations	Mean radioactivity concentration (fresh)[a], Bq kg^{-1}				
			^{241}Am	^{242}Cm	^{243}Cm + ^{244}Cm	Gross alpha	Gross beta
Marine samples							
Cod	Sizewell	2	<0.04				
Sole	Sizewell	2	<0.12				
Crabs	Sizewell	2	0.00091	*	*		
Lobsters	Sizewell	1	0.00083	*	0.000023		
Pacific oysters	Butley Creek	1	<0.04				
Pacific oysters	Blyth Estuary	1	<0.07				
Mussels	River Alde	2	<0.15				
Sediment	Rifle range	2[E]	<0.63				
Sediment	Aldeburgh	2[E]	<0.64				
Sediment	Southwold	2[E]	<1.4				920
Seawater	Sizewell	2[E]	<0.31			<3.4	15

RIFE – results for Sizewell (radioactivity in environmental samples) continued

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Table 4.8(a). Concentrations of radionuclides in food and the environment near Sizewell nuclear power stations, 2012

Material	Location or selection[b]	No. of sampling observ-ations[c]	Mean radioactivity concentration (fresh)[a], Bq kg^{-1}					
			^{3}H	^{14}C	^{35}S	^{137}Cs	Gross alpha	Gross beta
Terrestrial samples								
Milk		4	<4.3	17	<0.27	<0.19		
Milk	max		<4.5	20	<0.33	<0.20		
Apples		1	<4.0	10	<0.10	<0.30		
Barley		1	<7.0	88	1.1	<0.10		
Blackberries		1	<4.0	13	<0.10	<0.20		
Cabbage		1	<4.0	15	<0.20	<0.20		
Honey		1	<7.0	94	<0.10	<0.20		
Onions		1	<4.0	11	<0.10	<0.20		
Potatoes		1	<5.0	23	0.20	<0.20		
Runner beans		1	<4.0	6.0	0.40	<0.20		
Freshwater	Nature Reserve	2[E]	<3.0		<1.1	<0.20	<0.034	0.24
Freshwater	The Meare	2[E]	<3.0		<1.2	<0.19	<0.056	0.33
Freshwater	Leisure Park	2[E]	<4.2		<2.0	<0.20	<0.048	0.26

RIFE – results for Sizewell (radioactivity in environmental samples) continued

Table 4.8(a). Concentrations of radionuclides in food and the environment near Sizewell nuclear power stations, 2012

Material	Location or selection[b]	No. of sampling observ-ations[c]	Mean radioactivity concentration (fresh)[a], Bq kg^{-1}					
			^{134}Cs	^{137}Cs	^{155}Eu	^{241}Am	Gross alpha	Gross beta
Terrestrial samples								
Milk		12	<0.05	<0.05		<0.06		
Milk	max					<0.17		
Apples		3	<0.08	<0.07		<0.09		
Apples	max		<0.13	<0.12		<0.14		
Beef muscle		1	<0.05	0.07		<0.05		
Cabbage		2	<0.05	<0.05		<0.05		
Cabbage	max					<0.06		
Carrots		1	<0.05	<0.05		<0.05		
Cereals		1	<0.05	<0.05		<0.14		
Duck		3	<0.07	1.5		<0.09		
Duck	max		<0.09	1.9		<0.11		
Goose		5	<0.06	0.58		<0.10		
Goose	max		<0.08	0.89		<0.11		
Mixed root vegetables		1	<0.05	<0.05		<0.06		
Nettles		1	<0.05	<0.05		<0.07		
Rosehips		1	<0.05	<0.05		<0.06		
Wild blackberries		1	<0.05	<0.05		<0.05		
Grass		4	<0.05	<0.17		<0.10	<1.6	420
Grass	max			0.51		<0.11	4.3	460
Soil		4	<0.05	9.0	1.3	<0.18	180	1500
Soil	max		<0.07	11		<0.21	210	1600
Freshwater	Purdomstone	1	<0.01	<0.01		<0.01	<0.010	0.050
Freshwater	Winterhope	1	<0.01	<0.01		<0.01	<0.010	0.040
Freshwater	Black Esk	1	<0.01	<0.01		<0.01	<0.010	<0.010
Freshwater	Gullielands Burn	1	<0.01	<0.01		<0.01	<0.017	0.24

Methods

IAEA

ENVIRONMENT AGENCY
FOOD STANDARDS AGENCY
FOOD STANDARDS SCOTLAND
NATURAL RESOURCES WALES
NORTHERN IRELAND ENVIRONMENT AGENCY
SCOTTISH ENVIRONMENT PROTECTION AGENCY

Radioactivity in Food and the Environment, 2019 Appendix 1 CD Supplement

RIFE – 25

November 2020

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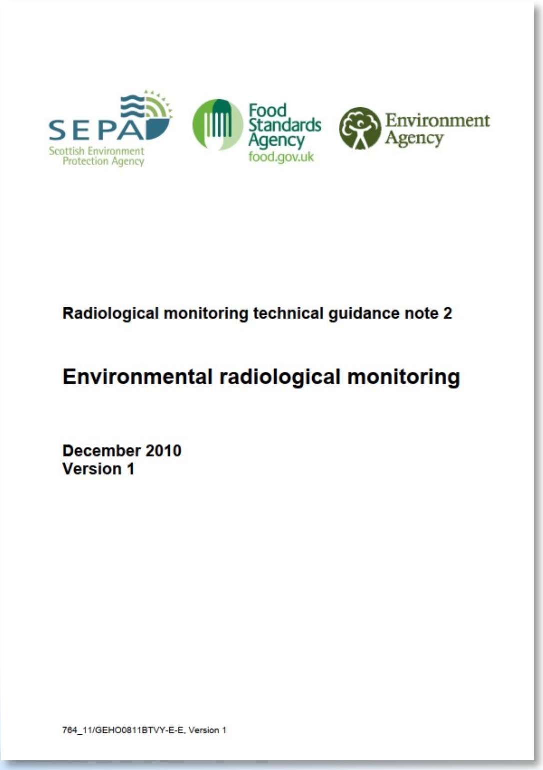


SEPA Scottish Environment Protection Agency

Food Standards Agency food.gov.uk

Environment Agency

Radiological monitoring technical guidance note 2

Environmental radiological monitoring

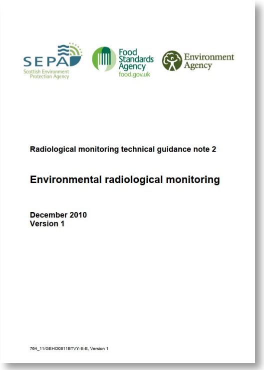
December 2010
Version 1

764_11/GEHO0811BTVY-E-E, Version 1

- Environmental monitoring objectives
- Environmental monitoring principles
- Process for designing environmental monitoring programmes
- Design of environmental monitoring programmes
- Quality Assurance
- Health, safety and environment
- Reporting, records, assessment and interpretation
- Appendix - Interpretation of IAEA Safety Standard (RS-G-1.8) for environmental monitoring associated with releases to air

https://www.gov.uk/government/publications/environmental-radiological-monitoring

UK Guidance - Environmental monitoring objectives


SEPA Scottish Environment Protection Agency
Food Standards Agency food.gov.uk
Environment Agency

Radiological monitoring technical guidance note 2

Environmental radiological monitoring

December 2010
Version 1

- Objective A - Assess total representative person (see definitions) dose
- Objective B - Assess dose as an operator’s performance measure
- Objective C - Assess total impact on wildlife (e.g. dose)
- Objective D - Assess impact on wildlife as an operator’s performance measure (e.g. dose)
- Objective E - Provide public and stakeholder reassurance.
- Objective F - Check / complementary monitoring
- Objective G - Assess background (very far field)
- Objective H - Assess long term trends (Indicator)
- Objective I - Comply with international obligations
- Objective J - Detect abnormal, fugitive and unauthorised releases (Indicator)
- Objective K - Understand / monitor behaviour of radio-nuclides in the environment

https://www.gov.uk/government/publications/environmental-radiological-monitoring

UK Guidance – Process for designing, implementing, and reviewing environmental radiological monitoring programmes

1. Collate information on source, pathway and receptors (e.g. previous monitoring, modelling, habit surveys etc.)
2. Assess monitoring site risk
3. Establish monitoring objectives (consult as required with stakeholdors and operators to agree objectives with regulators)
4. Determine what to monitor/sample, where and how often
5. Determine how to monitor/sample
6. Determine analysis and reporting requirements
7. Operators to formailize arrangements with regulator
8. Implement monitoring programme
9. Audit monitoring programme
10. Review monitoring programme

UK Guidance – example monitoring programme

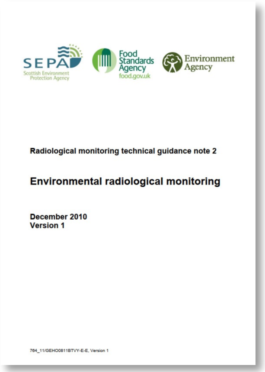

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Table 3 – Guidance on what to monitor, where and how often

This table indicates which programme is meeting an objective – i.e. regulator or operator through the use of prefixes R and O.
Where different samples/monitoring would be required to meet different objectives e.g. for the regulator programme, assess total representative person dose (Objective A) and assess background (Objective G) the components of the programme are indicated as R1 and R2.
Where the same samples/monitoring or a subset of these can be used to fulfil other objectives this is indicated by putting the objective code in brackets. For example for 3.4 in Table 3 "provide public and stakeholder reassurance" (Objective E) could be a sub-set of the "assess total representative person dose" hence for 3.4 of Table 3 against Objective E this is indicated as (R1). This does not indicate priority between the objectives, but is based on the objective for which the greatest number of samples is required.
For the assess background (very far field objective) (Objective G) if there is a national programme being undertaken there may be no need to take additional background samples for a particular site, hence the lower value of the range is zero.
Not all the sample/monitoring types in Table 3 will apply to every situation, for example sites with HVAS may not deploy passive shades and vice versa.
The "Differences for Historical Releases" column indicates whether a different sampling strategy would be required if historical discharges were being routinely monitored rather than current releases.

Sample / Monitoring type	Objectives		Data Requirements	Location	Frequency	Number Range / Year	Total No. of Samples / Year	Differences for Historical Releases
3.1 Dose Rate Monitoring (Terrestrial)	Assess total representative person dose	(R1)	μSvh^{-1} μSvy^{-1}	1-4 At location of max predicted dose and others determined from habit surveys [Discharges and direct radiation]	Continuous	1-4 continuous	**<u>Operator</u> Continuous 5-22 Or 4 - 120 spot** **<u>Regulator</u> Continuous 1 – 10 Or 4 - 120.2 spot**	No difference, also based on previous monitoring / knowledge / habit surveys
	Assess dose as an operator's performance measure	O1	μSvh^{-1} μSvy^{-1}	1-10 At location of max predicted dose and others determined from habit surveys [Discharges and direct radiation]	Continuous &/or monthly- quarterly spot measurement	1-10 continuous or 4-120 spot		As above
	Assess total impact on wildlife (e.g. dose)	(R1)	μGyh^{-1}	1-4 Targeted to sensitive habitats	Continuous	1-4 continuous		No difference
	Assess impact on wildlife as an operator's performance measure (e.g. dose)	(O1)	μGyh^{-1}	1-10 Targeted to sensitive habitats	Continuous &/or monthly -quarterly spot measurement	1-10 continuous or 4-120 spot		No difference
	Provide public & stakeholder reassurance	R1	μSvh^{-1} μSvy^{-1}	1-10 Targeting large population centres – maybe more distant &/or Max dose	Continuous &/or monthly- quarterly spot measurement	1-10 continuous or 4-120 spot		No difference
	Provide workforce reassurance	(O1)	μSvh^{-1} μSvy^{-1}	1-4 around site perimeter &/or Max dose	Continuous &/or monthly- quarterly spot measurement	1-4 continuous or 4-48 spot		No difference

UK Guidance - Interpretation of IAEA RS G-1.8

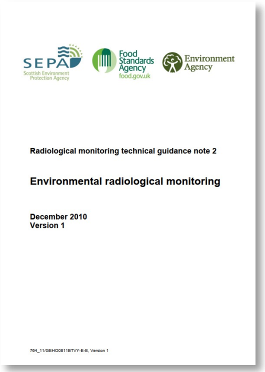
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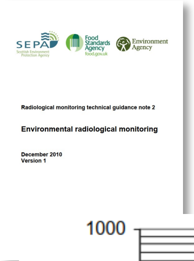
Table A1.1 Interpretation of IAEA Safety Standard for environmental monitoring associated with releases to air

Monitoring type	IAEA guidance	Minimal interpretation of IAEA guidance		Reasonable interpretation of IAEA guidance		Maximal interpretation of IAEA guidance	
		Description	Samples per year	Description	Samples per year	Description	Samples per year
Dose rate monitoring	Continuously	Continuously at maximum air concentration. On-line instrumental monitoring.	Every 10-15 s at 1 location	Continuously at maximum air concentration (1), nearby population centres (3) and background locations (2). On-line instrumental monitoring	Every 10-15 s at 6 locations	Continuously around site (5), at maximum air concentration (1), nearby habitation (5) and background locations (3). On-line instrumental monitoring	Every 10-15 s at 14 locations
Air	Continuously, monthly measurement	Continuously at maximum air concentration, monthly measurement	12	Continuously, monthly measurement at maximum air concentration (1), nearby population centres (3) and background locations (2)	72	Continuously, monthly measurement around site (4), at maximum air concentration (1), nearby habitation (4) and background locations (3).	144
Rain / total deposition	Continuously, monthly measurement	Continuously at maximum air concentration	12	Continuously at maximum air concentration (1), nearby population centres (3) and background locations (2)	72	Continuously, monthly measurement around site (4), at maximum air concentration (1), nearby habitation (4) and background locations (3).	144
Soil	Once per year	Once per year at maximum air concentration	1	Once per year at maximum air concentration (1), nearby population centres/farms (3) and background locations (2)	6	Once per year, around site (4), at maximum air concentration (1), nearby population centres/farms (4) and background locations (3)	12
Leafy vegetables	Every month during growing season	Every month during growing season (3 months) (1 type) at maximum air concentration	3	Every month during growing season (3 months) (2 types) at maximum air concentration (1) and other location (1)	12	Every month during growing season (3 months) (3 types) at maximum air concentration (1) and other locations (2)	27
Other vegetables and fruit	Selected samples at harvest	Selected samples (2 types) at harvest (once per year) at maximum air concentration	2	Selected samples (3 types) at harvest (once per year) at maximum air concentration (1) and other locations (2)	9	Selected samples (5 types) at harvest (once per year) at maximum air concentration (1) and other locations (3)	20

UK Guidance - Interpretation of IAEA RS G-1.8



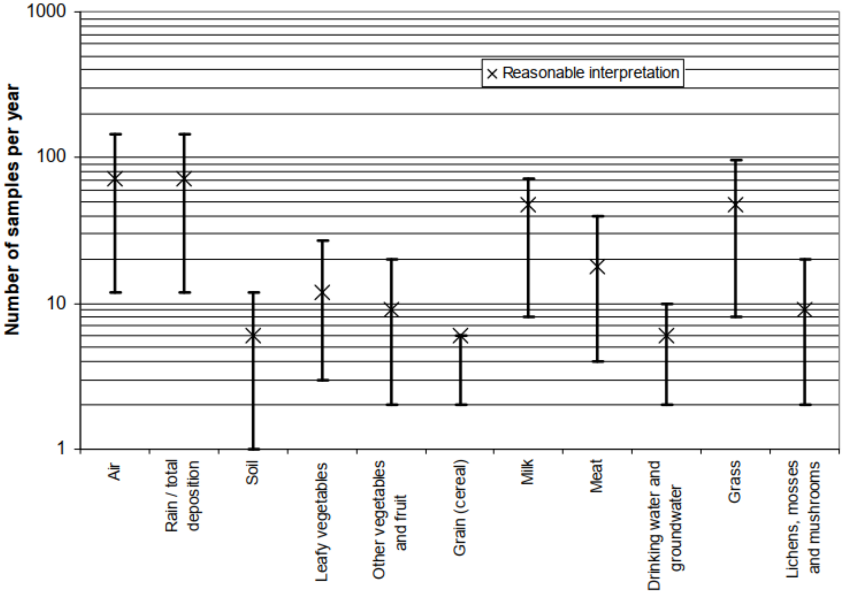


Figure A1.1 Interpretation of IAEA Guidance for number of samples – Releases to air

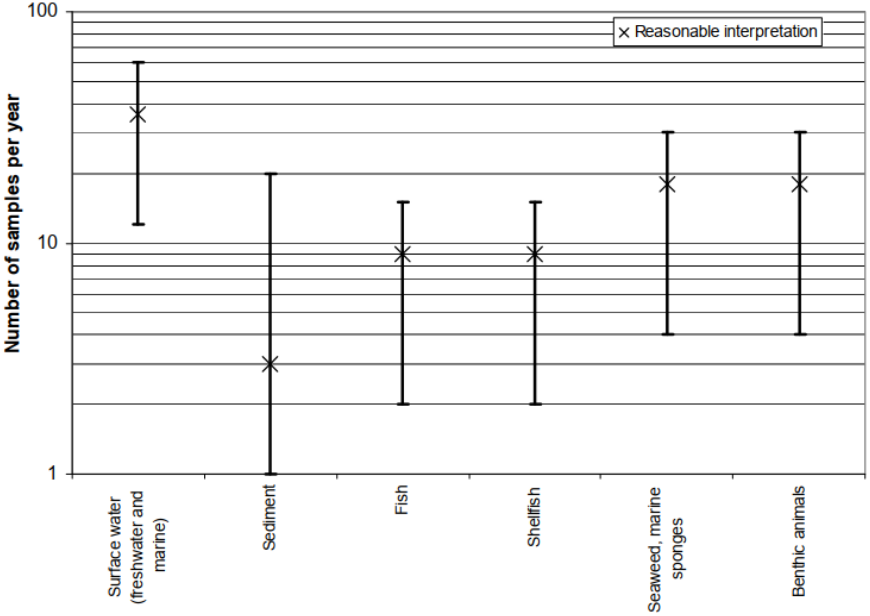


Figure A1.2 Interpretation of IAEA Guidance for number of samples – Releases to water

UK Guidance - Interpretation of IAEA RS G-1.8

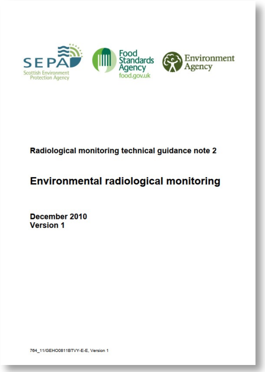
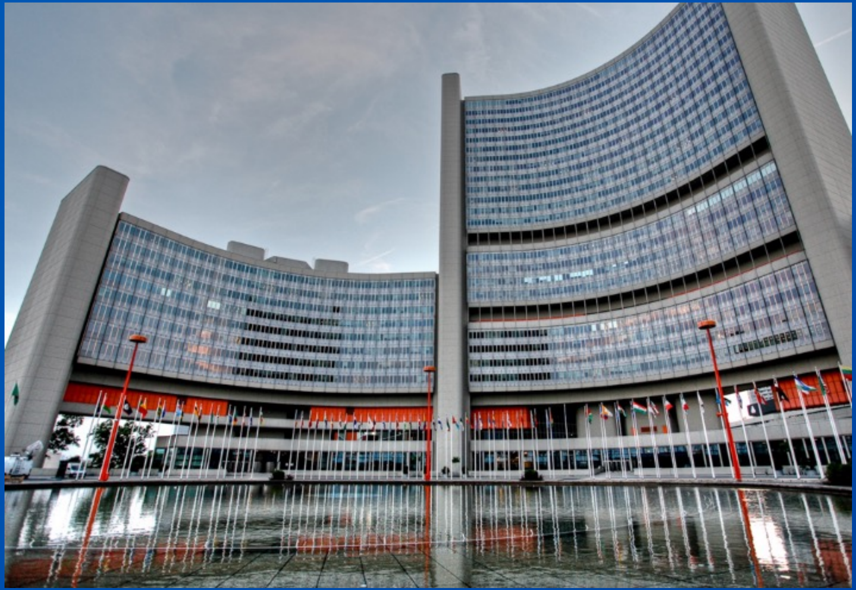


Table A1.2 Interpretation of IAEA Safety Standard for environmental monitoring associated with releases to water

Monitoring type	IAEA guidance	Minimal interpretation of IAEA guidance		Reasonable interpretation of IAEA guidance		Maximal interpretation of IAEA guidance	
		Description	Samples per year	Description	Samples per year	Description	Samples per year
Surface water (freshwater and marine)	Continuous sampling, monthly measurement	Continuous sampling, monthly measurement at one location	12	Continuous sampling, monthly measurement at a few locations (3)	36	Continuous sampling, monthly measurement at some locations (5)	60
Sediment	Once per year	Once per year at one location	1	Once per year at a few locations (3)	3	4 times per year at some locations (5). [Greater frequency of monitoring might be more appropriate for significant discharges].	20
Fish	Selected samples, once per year	Selected samples (2 types), once per year at one location	2	Selected samples (3 types), once per year at a few locations (3)	9	Selected samples (3 types), once per year at some locations (5)	15
Shellfish (e.g. mollusc, crustacean)	Selected samples, twice per year	Selected samples (2 types), once per year at one location	2	Selected samples (3 types), once per year at a few locations (3)	9	Selected samples (3 types), once per year at some locations (5)	15
Seaweed, marine sponges	Selected samples, twice per year	Selected samples (2 types), twice per year at one location	4	Selected samples (3 types), twice per year at a few locations (3)	18	Selected samples (3 types), twice per year at some locations (5)	30
Benthic animals (e.g. mollusc, crustacean)	Selected samples, twice per year	Selected samples (2 types), twice per year at one location	4	Selected samples (3 types), twice per year at a few locations (3)	18	Selected samples (3 types), twice per year at some locations (5)	30

IAEA
International Atomic Energy Agency
Atoms for Peace and Development



Thank you!
Questions?