Sellafield Ltd. Annual Review of Environmental Performance 2022/23

Introduction

Following publication of the 50th edition of our Discharges and Environmental Monitoring Report last year, we have revised the format of this report.

This new format publication outlines the variety of ways in which Sellafield Ltd. monitor our impacts on the environment, providing more balanced information across a range of impact types.

Carbon Footprint 2022/23

The Sellafield corporate carbon footprint for FY 2022/23 is in the region of 230k tonnes of CO_2e. This includes approximately 172k tonnes of CO_2e associated with electricity, steam, fuel consumption and process emissions (Scope 1 and 2 emissions). The remaining emissions are associated with a small proportion of our Scope 3 emissions.

In common with other businesses, our reporting of Scope 3 emissions is under development to increase the quality of data reported within the annual corporate carbon footprint to support our understanding of progress against our long-term carbon reduction targets. Previously business travel and commuting have been reported annually; for this financial year well to tank (WTT), transmission and distribution (T&D) and homeworking are also included. Whilst we are still developing the quality of data in the remaining Scope 3 categories, we have previously estimated the totality of our Scope 3 emissions to be approximately 600,000 tonnes of CO_2e.

It is anticipated that external verification of the corporate carbon footprint for FY 2022/23 will be completed in the summer of 2023/24.

Non-Radiological Impacts of Discharges & Monitoring of Non-radiological Pollutants in the Environment 2022 (Calendar Year)

The Installations environmental permit includes a requirement for a non-radiological monitoring programme. Compared to the radiological environmental monitoring programme, its scope is limited and comprises local air sampling on the Sellafield site, water sampling from the Rivers Calder and Ehen and seawater sampling from local beaches. A more comprehensive summary of non-radioactive releases to air, controlled waters, land and off-site transfers of waste is given in the Pollution Inventory supplied to the EA each year and is available from their website.

Measurements of nitrogen dioxide concentrations in air (using passive diffusion tubes) are made at five locations on the Sellafield site. Air sampling results show very low concentrations well within the UK Air Quality Standard [1].

Water samples are obtained from the Rivers Calder and Ehen at locations both upstream and downstream of the site. The downstream samples are taken above the confluence of the two rivers, and at times which minimise contamination with seawater. Seawater samples are obtained from the shoreline areas and confirm that the liquid discharges from Sellafield are not causing the Environmental Quality Standards (EQS) and Environmental Assessment Levels (EAL) [2] to be exceeded and therefore are of negligible impact.

Sellafield Ltd is committed to minimising the use of ozone depleting substances and fluorinated greenhouse gases and transitioning to more environmentally friendly alternatives where appropriate. Routine releases are estimated from the amounts of refrigerants used to top-up systems on site.

Monitoring of Sellafield's Landfill Sites 2022 (Calendar Year)

The Waste Management Licences for the North Landfill Site and Calder Floodplain Landfill Extensions require that environmental monitoring be carried out in the vicinity of the two sites. The monitoring comprises water sampling from the River Calder and New Mill Beck upstream and downstream of the landfills and gas monitoring over their surfaces. The results confirm that the impact of Sellafield's landfill sites remains negligible.

Radiological Dose Impacts 2022 (Calendar Year)

This report provides a summary of the comprehensive data that are available for inspection by members of the public on the Public Registers maintained by the Environment Agency.

There were no instances in 2022 of non-compliance with the numerical limits of permits regulating discharges and disposals of radioactive wastes at Sellafield. Radioactive discharges (aerial and liquid) were well below the permitted limits and were generally lower than those in 2021.

The estimated radiological doses to members of the public in 2022 are summarised in the table below. Doses to adult members of the marine critical group were estimated as 72 µSv, which is slightly higher than the dose estimated for 2021 (60 µSv) but in line with that in 2020 (70 µSv). The most significant radionuclides contributing to this dose are plutonium-alpha and americium-241, with the environmental concentrations of these radionuclides being mostly due to historic discharges and therefore changes in dose year on year reflect natural environmental variations.

Critical group doses from operations at Sellafield (µSv)		
Pathway	**2021**	**2022**
Marine critical group (adults)		
seafood consumption	24	28
aerial pathways	1.5	1.6
external radiation from beach occupancy (marine)	35	42
Total dose to marine critical group (adults)	**60**	**72**
Terrestrial critical group (adults)		
inhalation	0.52	0.6
immersion	0.03	0.005
external radiation from beach occupancy (terrestrial)	2.9	2.9
terrestrial foodstuff consumption	4.7	4.6
marine foodstuff consumption	0.58	0.55
direct radiation	2.9	3.0
Total dose to terrestrial critical group (adults)	**12**	**12**

The estimated dose in 2022 due to the consumption of terrestrial foodstuffs was about 5 µSv. Inclusion of dose contributions to this group from inhalation, immersion, external radiation from beach occupancy and marine. The total dose to the terrestrial critical group (adults) was estimated as 12 µSv which is unchanged from the dose reported for 2021.

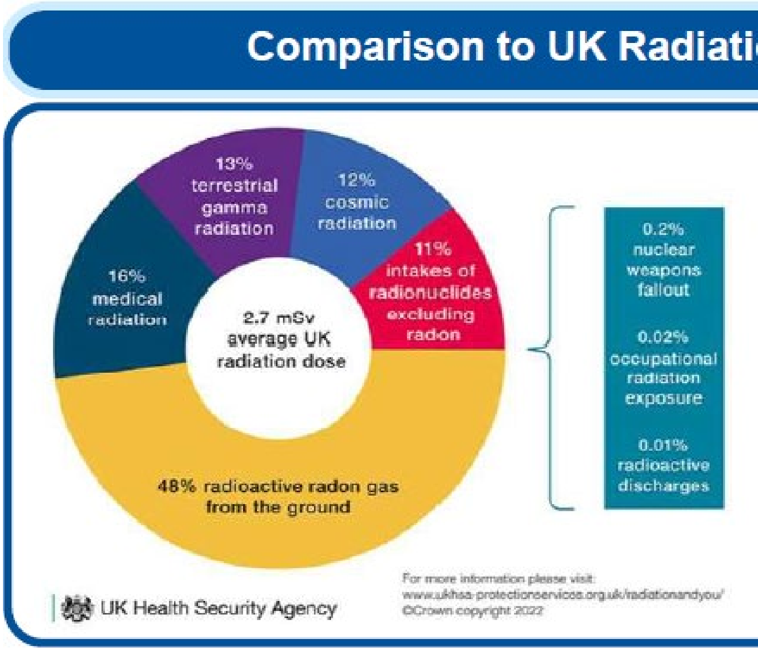
The range of doses estimated herein are comparable to those from regulators' programme and consistent conclusions are made that doses are well below the legal limit of 1000 µSv [3].

The distributions of caesium-137 and americium-241 activities for particles and larger objects recovered by the beach monitoring programme in 2022 were within the ranges previously observed and considered in the health risk assessment associated with public beach occupancy.

Independent environmental monitoring programmes and dose assessments are carried out and reported by government agencies and other groups [4–7].

Sellafield Ltd has contributed to a number of initiatives that developed criteria for the protection of the natural environment and carried out assessments of exposure against the guidelines given in national and international publications. On the basis of work to date there is no reason to believe that radioactive discharges from Sellafield Ltd are harming the natural environment and the dose assessments presented herein focus on the protection of human health.

The following visual is included as it is illustrative of the comparable dose impacts of Sellafield discharges versus various other sources of radiation exposure by the general public in the UK.



- Figure - Sources and Magnitudes of UK Population Exposure to Ionising Radiation Averaging 2700 µSv per year (UK)

The measurements in this report relate to environmental radioactivity that is mainly attributable to discharges from the Sellafield site. However, natural radioactivity makes an appreciable contribution to the reported values in some instances and it is important to recognise that natural radioactivity is the dominant source of radiation exposure to the population as a whole, including individuals living close to nuclear establishments.

In addition, the widespread radioactive fallout from the testing of nuclear weapons and from the Chernobyl accident make small contributions to overall doses. The subject has been reviewed comprehensively by UKHSA [8,9] and others [10]. Where corrections to account for background radiation are made they have been noted.

<u>In summary:</u>

The impacts of radioactivity in the environment local to the Sellafield site remain low, as per recent years, with only a small portion of this already low impact attributable to present operations on the site.

In contrast to earlier points in the site's history, the primary value of this extensive programme of environmental monitoring (in particular with respect to radioactivity in the environment) has moved on from measuring the impacts of the site's ongoing activities to:

- providing reassurance to both the public and other stakeholders,
- demonstrating compliance with both international obligations and our EPR (Environmental Permitting Regulations) permits - which directly place requirements on our environmental monitoring programme,
- providing reassurance monitoring to SL ourselves, by allowing the detection of any abnormal or fugitive releases to the environment.

Monitoring for Radioactivity in the Environment 2022 (Calendar Year)

Statutory Environmental Monitoring Programme

The Statutory Environmental Monitoring Programme (SEMP) provides public and stakeholder assurance that the environmental impacts of the Sellafield site are minimized according to the principles of Best Available Techniques (BAT).

In terms of radiological protection the SEMP has the following remit:

- to take account of the most important pathways of radiation exposure to the public;
- conduct appropriate sampling and analysis relevant to those pathways; and
- to combine monitoring and habits data to yield estimates of radiation doses to the public.

The results of the Sellafield Ltd environmental monitoring programme for 2022 are presented within this report alongside supplementary data published by the FSA (from 2021) [11].

The main pathways identified by Sellafield Ltd, the EA and FSA as relevant to calculating radiological doses from discharges from the Sellafield site are:

- Internal exposure from the high rate consumption of seafood (particularly crustaceans and shellfish) and of local agricultural produce;
- External gamma radiation from exposed intertidal sediments, particularly the silts and muds of estuaries and harbours; and,
- Inhalation of, and exposure to, airborne radioactivity.

Marine Monitoring

Concentrations of radionuclides in seafoods (fish, molluscs and crustaceans) were very low and comparable to previous years data. The slight increases in actinide concentrations in seafood are due to historically discharged material that associates with fine silts and sediments.

Concentrations of radioactivity in seaweed, seawater and in sediments were broadly similar to those of recent years.

Gamma dose rate surveys are carried out in the areas most often frequented by members of the public and the site perimeter and the surrounding district. Particular attention is paid to areas where silt or mud accumulates, such as in harbours or estuaries, where dose rates tend to be higher because of the presence of finely-divided sediments. In general gamma dose rates are declining towards background levels and are consistent with the radioactive decay of key gamma emitting radioisotopes (cobalt-60, ruthenium-106 and caesium-137).

Water samples are collected from rivers (Calder and Ehen), lakes and domestic supplies. The results are all very low and rarely above the limits of detection, except for strontium-90 which is generally present in rainwater and surface water at levels typical of those throughout the UK.

Higher strontium-90 concentrations are measured in the River Calder at Sellafield due to seepage of groundwater from site to the river. This radioisotope is thought to be present in due to the historic leak to ground due to historic leaks to ground and measurements have determined that elevated concentrations in the river occur immediately upstream of the statutory sampling point. There is no evidence of any elevated levels of strontium-90 in any other environmental media (seawater or seafoods) and the contribution of strontium-90 to external doses is minimal. Hence, the overall public dose consequences of these elevated levels would be insignificant. Nevertheless, a watching brief will be kept on the situation to ensure that these conclusions remain valid.

Beach Monitoring

The beach monitoring programme for 2022 conducted a total of 117 ha of beach monitoring against the programme target of 105 ha. A total of 49 particles and 7 larger objects were detected, recovered, and analysed. Of these, 46 were alpha rich particles (where radioactivity was dominated by Am-241); 2 were beta rich particles (where radioactivity was dominated by Cs-137) and 1 other particle was found to be dominated by Co-60. All the 7 beta rich larger objects were recovered from Sellafield beach). Find rates and radioactive contents in 2022 did not required any form of intervention through the EA notification and intervention protocol [12].

Terrestrial Monitoring

High volume air samplers (HVAS), located close to the site perimeter and in nearby centres of population, are used to measure particulate radionuclides. Levels on site were generally similar to previous years although slightly higher concentrations of caesium-137 and plutonium-alpha were recorded at the Met Station location.

These data were used as part of an investigation into the contamination of ventilation system inlet filters where total activity above the normal range was detected, identified to correspond to a period of elevated arisings at the HVAS. Following investigation all filters have been classified as VLLW and the worst case dose calculated to be <1% of the site total through gaseous pathways. Off-site data were generally below the limit of detection, with most positive values reflecting sea to land transfer from marine discharges.

Total deposition collectors are located in the vicinity of each of the five high volume air samplers close to the site perimeter. Higher activity concentrations for beta-emitters (Strontium-90 and Caesium-137) were measured at North Gate, reflecting its close proximity to the open ponds and were also considered as part of the inlet filters investigation.

Sampling for atmospheric krypton-85 is conducted at the Sellafield Meteorological station on the edge of Sellafield site. Concentrations averaged 2.2 Bq m^{-3} with global background accounting for approximately 1.6 Bq m^{-3} and the discharges from the site accounting for approximately 0.6 Bq m^{-3}. This is equivalent to an immersion dose due to krypton-85 discharges from Sellafield of 0.005 µSv per year for the adult age group. These results are so low, in fact, that the monitoring and reporting Kr-85 will cease from this point onwards.

The milk results for 2022 are broadly similar to, or lower than, those observed for previous years, with many analyses at the limit of detection. Concentrations in soil are similar to previous years whilst there was some evidence of enhanced grass concentrations and these data were used for the contaminated inlet filter investigation. Potatoes are collected from farms close to the site and rabbits are collected on site. Measured concentrations were very low and typical of data from recent years.

Direct radiation

Dose rates at the site perimeter, corrected for natural radiation, averaged 0.02 µGy per hour, which is slightly elevated over natural background. Dose rates in the surrounding district were consistent with natural terrestrial background radiation and did not show a significant contribution from the Sellafield site. An assessment of the maximum theoretical direct shine offsite dose to members of the public illustrated that doses could be approximately 3 µSv per year to people living and working adjacent to the site boundary.

Impacts on Local Groundwater

Sellafield Ltd undertakes groundwater monitoring to characterise and monitor groundwater quality and the environmental fate of in-ground contamination across the Sellafield site. The groundwater monitoring network, in various configurations, has been in place for over 40 years and a considerable baseline dataset is available. In addition, groundwater monitoring is undertaken in order to comply with site Environmental Permits. The management of groundwater is underpinned by a Best Available Technique assessment.

The groundwater monitoring network for 2022 included 250 sample points across the site and adjacent land, targeting both bedrock (sandstone – principal aquifer) and superficial deposits and was designed to meet the monitoring objectives and provide targeted sampling in areas of interest. In terms of spatial distribution of groundwater contaminants the routine groundwater monitoring results in 2022 (calendar year) were broadly similar to those reported in recent years.

Following the notification of a leak to ground from Magnox Swarf Storage Silo (MSSS) in late 2019, it was recognised that the release of silo liquor would likely be identified by an increase in the concentration of specific radionuclides in groundwater samples around MSSS, particularly those radionuclides that have a low sorption to soil minerals, such as Tritium (H-3), Technetium (Tc-99), Chlorine (Cl-36) and Carbon (C-14). In December 2019 an enhanced groundwater monitoring programme was introduced. This included monitoring arrays of 15 monitoring wells in close proximity to MSSS, 8 slightly further away in the vicinity of the redundant settling tanks (RST) along the buried channel pathway and 4 to the south of the Separation Area.

This enhanced monitoring aimed to observe any changes in the physical and chemical properties of groundwater both spatially and temporally. The initial enhanced monitoring programme involved monthly sampling for broad analysis (*i.e.,* gross beta, gross alpha, tritium) and quarterly detailed analysis with speciation of specific radionuclides and inorganic parameters.

Following observed rising trends of tritium and identification of specific radionuclides attributed to the current leak in the late Spring / early Summer 2021, routine monitoring of the borehole array closest to MSSS was further enhanced to incorporate a monthly detailed analysis. Monitoring of the next distal array of wells out from MSSS was also enhanced from quarterly to monthly from Summer 2021. Work is ongoing to review and optimise the enhanced groundwater monitoring programme, based on analysis of the monitoring data collected since the start of the current leak to ground, and embed the programme within the routine sitewide groundwater monitoring programme.

The groundwater sampling programme provides crucial information on the impacts of site activities to groundwater, including identifying the contaminants of concern, the direction of contaminant migration, the dimensions and shape of the emerging/ historical plumes and which groundwater pathways drive the highest risk. Monitoring results may also be used to understand the prevailing geochemical processes and support any assessment required to evaluate environmental risk, including the potential for natural attenuation.

A summary of information on groundwater monitoring at the Sellafield site can be found in the Triennial Groundwater Reports, the first of which was published in 2021 and covers activities between 2017 and 2019. The second iteration, covering 2020-2022, will be published in October 2023.

Impacts of Solid Waste Dispositions 2022/23

Ensuring that the BAT waste route is used and diverting waste from the Low Level Waste Repository continues, the Waste OU have reduced the accumulation of waste being stored on site by transferring radioactive waste to either an interim store, an onsite landfill, sent offsite for treatment, incineration or if there are no other routes, for the waste to be consigned to the repository.

Remediation completed a clean-up operation on the external areas of the Sellafield Site. This led to equipment such as barriers, road signs and fencing being reused by Infrastructure and projects which has kept these items being used as part of the circular economy principles by these items not becoming waste.

The recycling rate for non-radioactive waste was 94% which was an increase of 3% from the previous year. This reduces our impact on the environment by utilising the Waste Management Hierarchy by diverting waste from landfill sites.

The collation of data on the carbon footprint for non-radioactive waste vehicles moves was initiated in 2022/23 and further developments in capturing this data will continue in 2023/24.

References

[1] HMSO (2010). The Air Quality Standards Regulations. Available online at https://www.legislation.gov.uk/uksi/2010/1001/contents/made

[2] Environment Agency (2022). Risk assessments for your environmental permit. Available online at https://www.gov.uk/guidance/risk-assessments-for-your-environmental-permit

[3] Cmnd 2919 (1995). Review of radioactive waste management policy: Final conclusions. HMSO, London.

[4] McKay W A and Stephens B A (1990). A survey of fish and shellfish radioactivity levels in Cumbrian near- shore waters, 1989. AEA-EE-0041, Harwell.

[5] McKay W A and Walker M I (1990). Plutonium and americium behaviour in Cumbrian near-shore waters. J. Environ. Radioactivity 12: 49-77.

[6] Walker M I and McKay W A (1991). Radionuclide distributions in seawater around the Sellafield pipeline. Est. Coast. Shelf Sci. 32: 385-393.

[7] Isle of Man Government Laboratory (2011). Radioactivity monitoring on the Isle of Man 2010.

[8] Watson S J, Jones A L, Oatway W B and Hughes J S (2005). Ionising radiation exposure of the UK population: 2005 Review. UK HSA Report HPA-RPD-001, HMSO, London.

[9] Hughes J S and Shaw K B (1996). Radiation doses from natural radiation. NRPB Report M748.

[10] Saunders P (1990). Radiation and you. Banson.

[11] Environment Agency, Food Standards Agency, Food Standards Scotland, Natural Resources Wales, Northern Ireland Environment Agency and Scottish Environment Protection Agency (2022). Radioactivity in food and the environment, 2021. RIFE-27. EA, FSA, FSS, NRW, NIEA and SEPA; Preston, London, Aberdeen, Cardiff, Belfast and Stirling.

[12] Environment Agency (2020). Sellafield radioactive objects notification and intervention plan, Penrith: Environment Agency. Available online at: https://www.gov.uk/government/publications/sellafield-radioactive-objects-notification-and-intervention-plan/sellafield-radioactive-objects-notification-and-intervention-plan

Appendix A to the Annual Review of Environmental Performance

Figure 1. Marine environmental monitoring around Sellafield

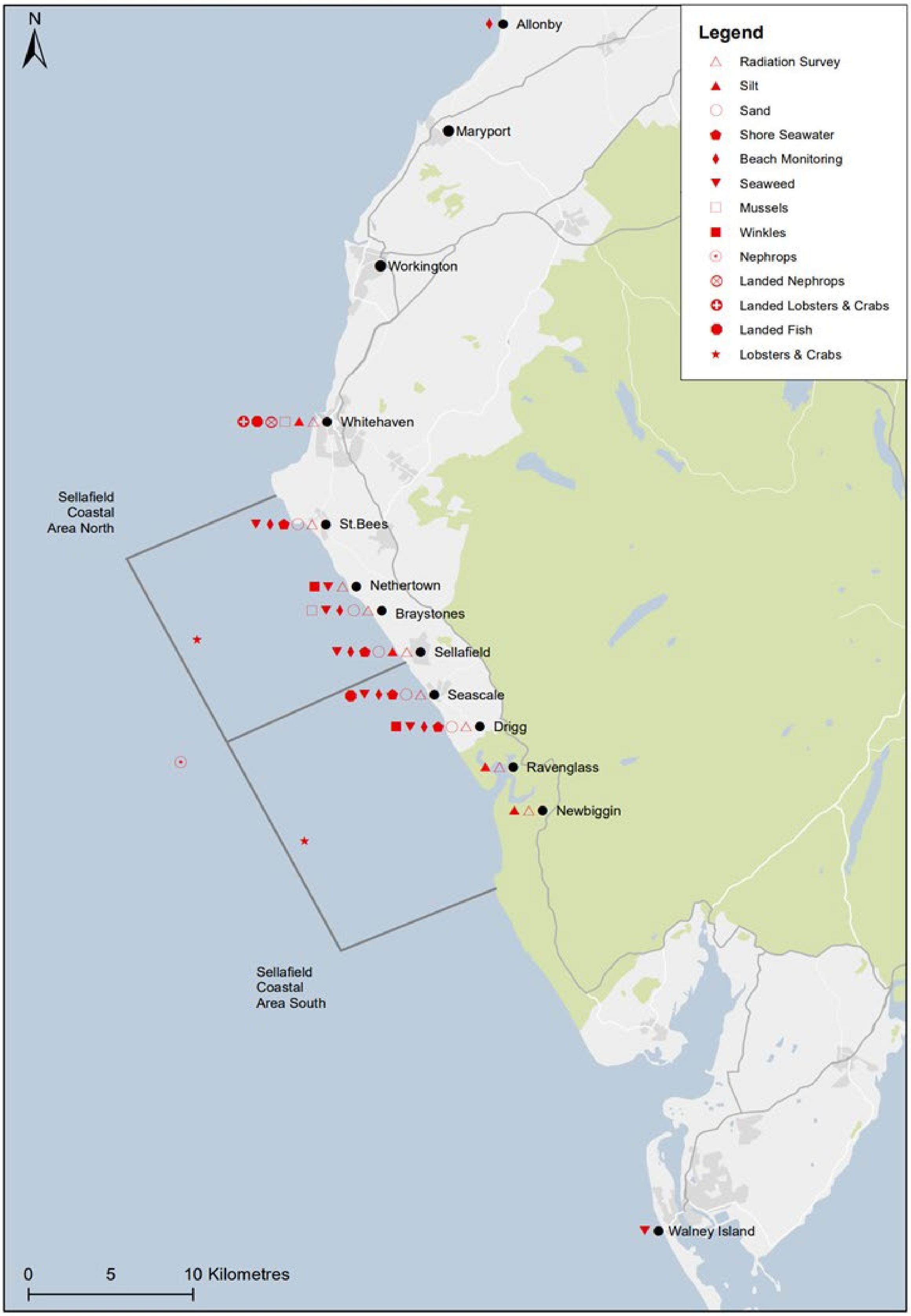


Figure 2. Terrestrial environmental monitoring around Sellafield

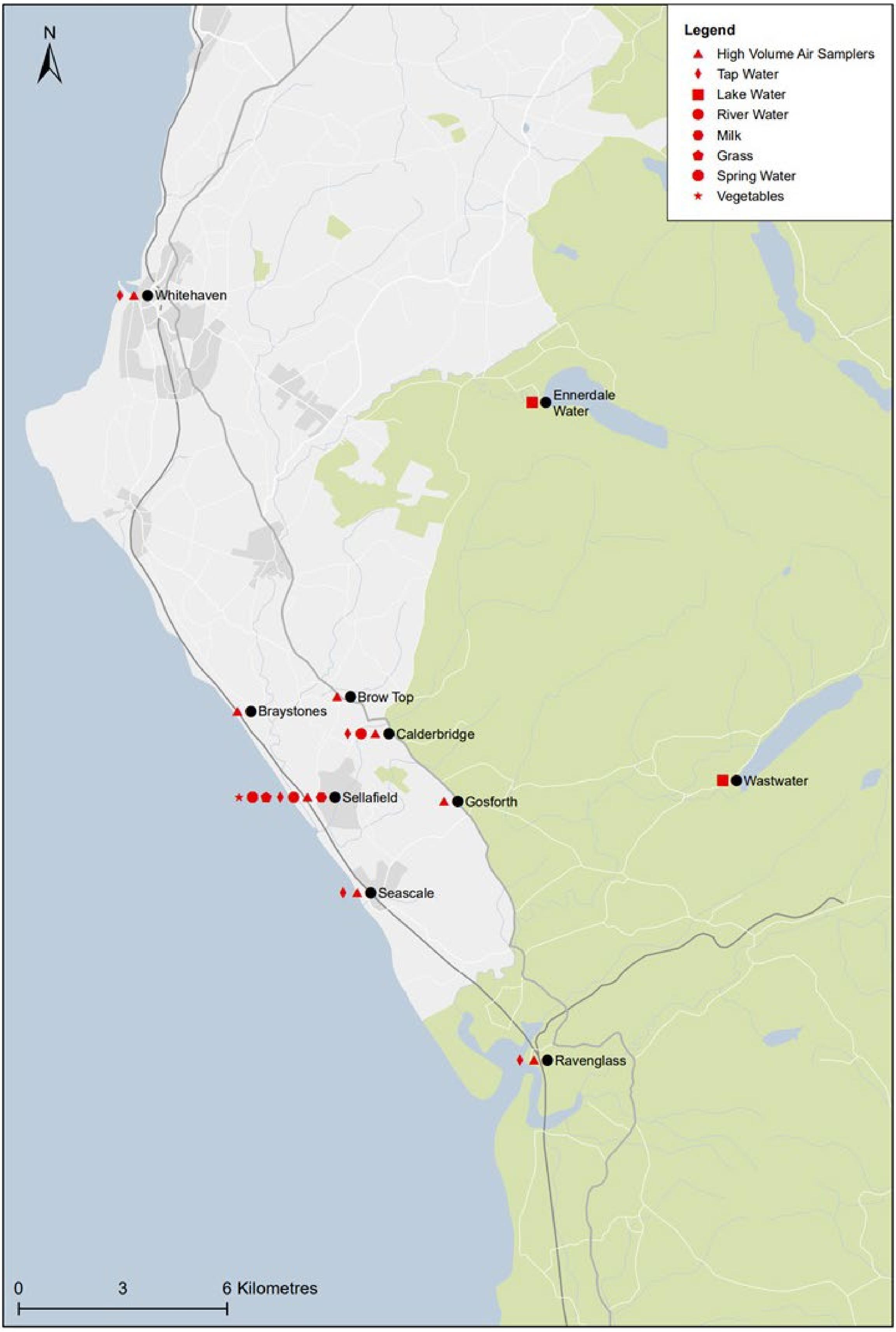
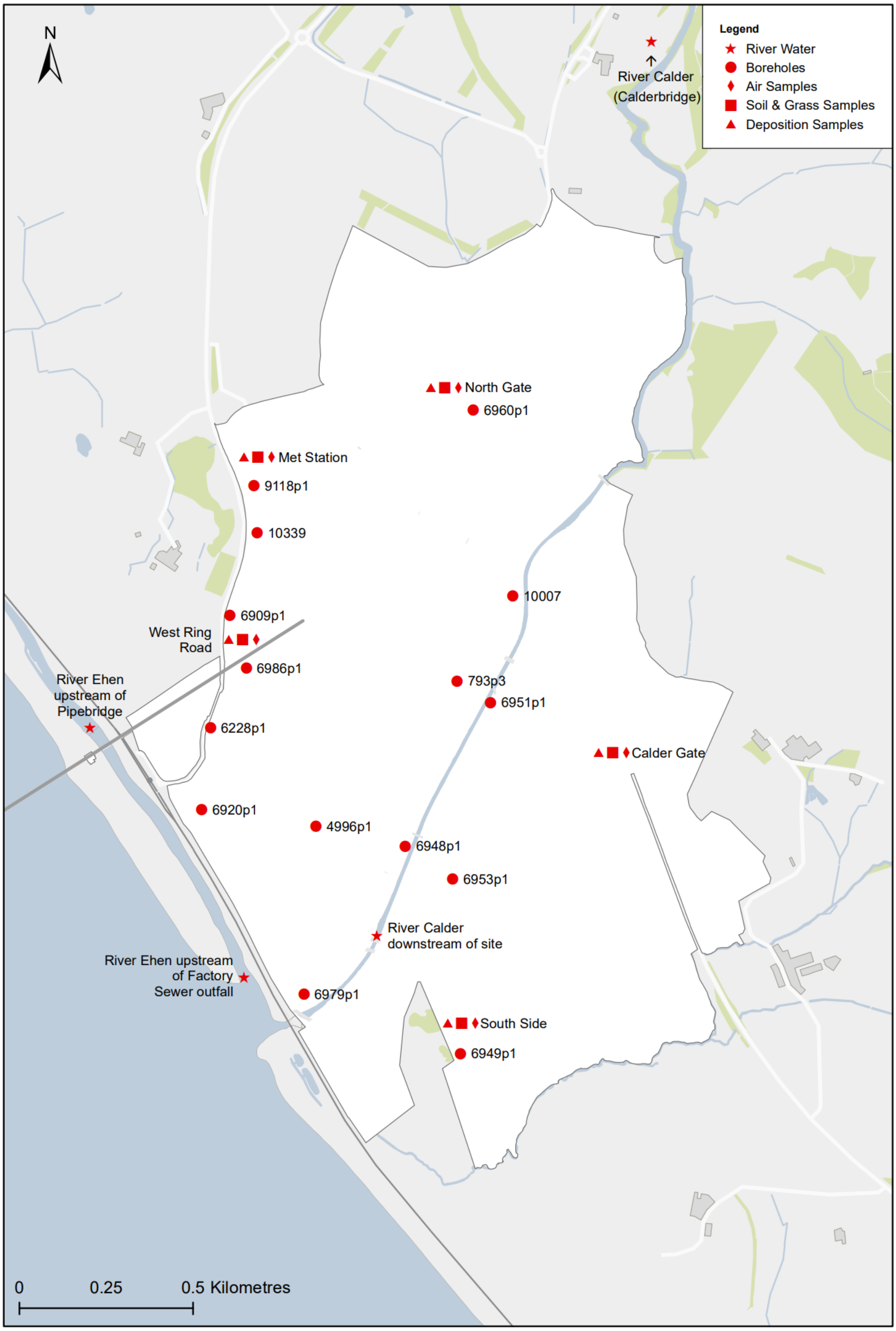


Figure 3. Environmental monitoring at the Sellafield site



Discharge Data Tables

Table 1. Radioactive discharges to the Irish Sea, 2018 – 2022.

Radionuclides	Annual discharge (TBq)					Permitted Limits
	2018	2019	2020	2021	2022	
Tritium[c]	1,300	420	190	180	130	3,000/700[b]
Carbon-14	2.9	2.8	1.2	1.3	0.85	13/5.1[b]
Cobalt-60	0.02	0.02	0.02	0.01	0.01	2.5
Strontium-90	1.3	1.2	1.4	2.4	1.8	14
Zirconium-95	0.03	0.03	0.03	-	0.02	-
Niobium-95	0.03	0.02	-	-	0.01	-
Technetium-99	0.93	0.94	0.62	0.48	0.35	7.5/4.5[b]
Ruthenium-106	0.54	0.46	0.27	0.17	0.16	3.1
Iodine-129	0.30	0.04	0.03	0.02	0.02	0.32
Caesium-134	0.04	0.02	0.03	-	-	-
Caesium-137	4.4	1.6	2.5	1.4	1.3	17
Plutonium-alpha	0.14	0.11	0.10	0.08	0.07	0.29
Plutonium-241	1.9	1.2	1.1	0.83	0.73	6
Americium-241	0.02	0.02	0.01	0.01	0.01	0.14
Total alpha[ac]	0.16	0.13	0.12	0.09	0.08	0.34
Total beta[ac]	-	6.8	7.1	7.4	6.5	63
Uranium (kg)	310	260	180	130	110	-

a 'Total alpha' and 'Total beta' are control measures relating to specified analytical determinations. They do not reproduce precisely the contributions from all individual isotopes.

b Upper tier of permitted limit in force until the completion of Magnox reprocessing. Lower teir limits for tritium, carbon-14 and technetium-99 applied from October 2022 onwards following agreement with the EA.

Table 3. Total airborne radioactive discharges, 2018 – 2022

Radionuclides	2018	2019	2020	2021	2022	Permitted Limits (all sources)
	Annual discharge (TBq)					
Tritium	90	56	38	39	15	370/170[a]
Carbon-14	0.43	0.25	0.13	0.07	0.09	2.3/0.38[a]
Krypton-85	65,000	7,800	4,300	4,300	2,500	70,000
	Annual discharge (GBq)					
Strontium-90	0.01	0.009	0.01	0.004	0.003	0.50
Ruthenium-106	0.49	0.56	0.55	0.55	0.61	2.8
Antimony-125	1.3	1.5	1.1	0.53	0.41	30
Iodine-129	10	3.2	2.1	1.8	1.8	42/13[a]
Caesium-137	0.05	0.07	0.08	0.05	0.04	4.8
Plutonium-alpha	0.03	0.01	0.01	0.009	0.006	0.13
Americium-241 + Curium-242	0.02	0.01	0.01	0.009	0.009	0.08
Total alpha	0.10	0.08	0.10	0.07	0.07	0.66
Total beta	0.66	0.64	0.74	0.70	0.90	32

a Upper tierof permitted limit in force until the completion of Magnox reprocessing. Lower teir limits for tritium, carbon-14 and iodine 129 applied from October 2022 onwards following agreement with the EA.

Table 4. Solid low level waste arisings from Sellafield, 2018 – 2022

Low level waste arisings (m³)	2018	2019	2020	2021	2022
LLW produced on site which has been reused, recycled or disposed of	9,000	9,400	5,100	12,000	8,200
LLW metal waste recycled	3,100	2,900	1,700	140	800
Combustible LLW treated	2,200	2,100	2,500	2,100	2,400
LLW disposed of directly to landfill (as LLW, HV-VLLW or exempt waste but excluding waste that is out of scope of regulation)	580	850	210	400	320
LLW disposed of on site	2,300	3,100	600	9,300	4,000
Volume of LLW disposed of at LLWR	880[a]	520[a]	80	300	600

a Volume includes volume of compactable LLW.

Table 5. Non-radioactive aqueous waste discharges (kg), 2018 – 2022

Substance	Release points	2018	2019	2020	2021	2022	Annual Limit[a]
Chromium	SIXEP, SETP, EARP	40	5.6	14	4.1	13.7	1,200
N as NO_2 and NO_3	SETP, EARP	1,000,000	1,000,000	410,000	590,000	311000	4,080,000
N as NO_2 and NO_3	Thorp-C14 Removal Plant	4,600	420	110	260	55	26,900
Glycol	SETP, SIXEP, EARP, Lagoon	1,500	7,600	2,000	3,400	9,800	12,000

a Annual mass limits reported under the Installations environmental permit.

Table 6. Non-radioactive gaseous waste discharges (kg), 2018 – 2022

Substance	Release points	2018	2019	2020	2021	2022	Annual Limit[a]
Oxides of nitrogen (as NO_2)	Vitrification Test Rig	33	40	43	48	26	1,000
Oxides of nitrogen (as NO_2)	NNL Central Laboratory	14	11	5.4	7.3	2.2	500
Particulate matter	Fellside CHP (as PM_{10})	360	230	190	160	324	-

a Annual mass limits reported under the Installations environmental permit.

Table 7. Non-radioactive gaseous waste discharges (tonne), 2018 – 2022

Substance	Release points[a]	2018	2019	2020	2021	2022
Oxides of nitrogen (as NO_2)	Site Total	330	250	180	83	90
Carbon dioxide	Site Total	320,000	260,000	260,000	137,000	156,000
Carbon monoxide[b]	Site Total	42	0.03	17	6.94	14.26
Non-Methane Volatile organic compounds (NMVOCs)	Site Total	63	32	23	23	22
Methane	Site Total	17	0.01	14	10	7.99

a Site Total includes Fellside CHP plant.
b EA agreed reporting value as carbon monoxide discharges significantly below reporting threshold (BRT) values.

Table 8. Discharges of ozone depleting substances and fluorinated greenhouse gases (kg), 2018 - 2022

Substance[a]	2018	2019	2020	2021	2022
R22 HCFC	-	4	-	-	0.5
R134A HFC	70	1000	320	203	1284
R407C HFC	19	50	100	70	39.4
R404A HFC	5.3	3.6	-	7	2.1
R410A HFC	12	82	42	56	80

a HCFCs are ozone depleting substances and HFCs are fluorinated greenhouse gases.

Note: the range of substances discharged varies each year depending on which equipment is topped up with refrigerants. No annual mass limits apply.

Table 9. Non-radioactive solid waste arisings from Sellafield, 2018 – 2022

	Non-Radioactive Waste Arisings (te)	2018	2019	2020	2021	2022
Non-Hazardous Waste Arisings	Non-hazardous waste produced on site	38,000	92,000	43,000	22,000	24,000
	Non-hazardous waste reused or recycled	9,300	2,800	30,000	21,000	24,000
	% of non-hazardous waste reused or recycled	24 %	3.1 %	69%	94%	>99%
Hazardous Waste Arisings	Hazardous waste produced on site	1,200	1,100	2,900	1,700	1,400
	Hazardous waste reused or recycled	500	99	170	290	135
	% of hazardous waste reused or recycled	42 %	9.2 %	5.8%	17%	9.8%

Whilst every effort is made to centrally record all Non-Rad waste arisings, some sub-contractors may not provide this information, so the actual quantity produced may be higher than the centrally recorded figure. Note that no annual mass limits apply.

Environmental Monitoring Data

Table 10. Radioactivity in fish (Bq kg^{-1} wet weight), 2022

Species	Location	Mean radionuclide concentration (Bq kg^{-1} wet weight)				
		$^{14}C^{a}$	^{99}Tc	^{137}Cs	Pu(α)	^{241}Am
Cod	Seascale landed	33	<0.31	2.5	<0.003	<0.003
	Whitehaven landed	31	<0.26	2.9	<0.004	0.006
Plaice	Seascale landed	39	1.5	0.99	0.006	0.006
	Whitehaven landed	38	1.9	0.93	0.008	0.007

a ^{14}C data include natural background

Table 11. Radioactivity in molluscs (Bq kg^{-1} {wet weight}), 2022

Species	Location	Mean radionuclide concentration (Bq kg^{-1} wet weight)																
		Total Alpha	Total Beta	$^{14}C^{a}$	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{129}I	^{137}Cs	U(α)	^{237}Np	Pu(α)	^{238}Pu	$^{239+240}Pu$	^{241}Pu	^{241}Am	Cm(α)
Mussels	SCAN – A	-	-	67	-	0.26	10	-	-	-	0.76	-	2.5	0.38	2.2	8.8	5.4	-
	SCAN -	12	51	-	0.48	-	-	<0.64	-	1.1	-	-	-	-	-	-	5.0	-
	SCAN –	22	67	-	0.36	-	-	<0.88	-	0.76	-	-	-	-	-	-	5.1	-
	SCAN	17	59	67	0.42	0.26	10	<0.76	-	0.93	0.76	-	2.5	0.38	2.2	8.8	5.2	-
	WH - Al	-	-	40	-	0.13	11	-	-	-	0.79	-	1.9	0.28	1.6	5.8	3.3	-
	WH - Bl	9.5	43	-	0.07	-	-	<0.57	-	0.51	-	-	-	-	-	-	1.7	-
	WH - Bl	8.8	57	-	<0.08	-	-	<0.76	-	0.92	-	-	-	-	-	-	3.8	-
	WH Ave.	9.2	50	40	<0.08	0.13	11	<0.67	-	0.72	0.79	-	1.9	0.28	1.6	5.8	2.9	-
	SCA Ave.	**13**	**55**	**54**	**0.25**	**0.20**	**11**	**<0.71**	**-**	**0.82**	**0.78**	**-**	**2.2**	**0.33**	**1.9**	**7.3**	**4.1**	-
Winkles	SCAN - Al	-	-	44	-	-	-	-	<0.16	-	-	-	-	-	-	-	-	-
	SCAN – Q	48	110	-	0.43	2.0	39	<0.88	-	6.6	2.7	0.02	12	1.7	9.9	39	22	<0.11
	SCAN – Q	52	96	-	0.58	0.98	16	<0.91	-	5.9	2.0	0.01	11	1.6	9.4	36	19	0.04
	SCAN – Q	18	90	-	0.37	1.3	10	<0.75	-	2.8	1.3	0.007	5.2	0.70	4.5	17	9.5	<0.08
	SCAN – Q	14	60	-	0.31	0.58	22	<0.76	-	1.5	1.3	0.005	3.5	0.46	3.0	10	6.8	0.03
	SCAN	33	89	44	0.42	1.2	22	<0.83	<0.16	4.2	1.8	0.01	7.9	1.1	6.7	26	14	<0.07
	SCAS – A	-	-	69	-	-	-	-	<0.14	-	-	-	-	-	-	-	-	-
	SCAS – Q	27	86	-	0.45	0.44	50	<0.67	-	1.5	2.7	0.007	5.5	0.74	4.8	19	8.6	<0.05
	SCAS – Q	40	100	-	0.58	0.89	66	<0.85	-	3.8	3.0	0.01	9.6	1.5	8.0	33	14	<0.05
	SCAS – Q	18	82	-	0.48	0.64	19	<1.1	-	1.8	1.7	0.005	4.3	0.59	3.7	15	9.0	<0.06
	SCAS – Q	31	83	-	0.48	0.68	32	<1.0	-	1.6	2.2	0.006	5.1	0.79	4.3	17	8.4	0.03
	SCAS	29	88	69	0.50	0.66	42	<0.91	<0.14	2.2	2.4	0.007	6.1	0.91	5.2	21	10	<0.05
	SCA Ave.	**31**	**88**	**57**	**0.46**	**0.94**	**32**	**<0.87**	**<0.15**	**3.2**	**2.1**	**0.009**	**7.0**	**1.0**	**6.0**	**23**	**12**	<0.06

Notes: SCA – Sellafield Coastal Area; N – North, S- South, A – Annual sample, B – Biannual sample, Q – Quarterly sample, Ave.- Average.

Table 12. Radioactivity in crustaceans (Bq kg^{-1} wet weight), 2022

Species	Location		Mean concentration (Bq kg^{-1} {wet weight})							
		$^{14}C^{a}$	^{60}Co	^{90}Sr	^{99}Tc	^{129}I	^{137}Cs	U(α)	Pu(α)	^{241}Am
Edible Crab	SCA (north) - Early	50	-	0.04	3.3	-	0.44	0.15	0.13	0.65
	SCA (north) - Late	84	-	0.10	5.6	-	0.41	0.29	0.27	0.99
	SCA (north) Average	67	-	0.07	4.5	-	0.43	0.22	0.20	0.82
	SCA (south) - Early	63	0.20	0.10	7.0	-	0.54	0.23	0.16	0.78
	SCA (south) - Late	72	-	0.09	4.2	-	0.42	0.28	0.19	0.65
	SCA (south) Average	68	0.20	0.10	5.6	-	0.48	0.26	0.18	0.72
	SCA Average	**67**	**0.20**	**0.08**	**5.0**	**-**	**0.45**	**0.24**	**0.19**	**0.77**
	WL - Early	72	-	<0.07	5.0	-	0.48	0.13	0.16	0.66
	WL - Late	70	-	0.10	3.6	-	0.48	0.29	0.20	0.85
	WL - Average	**71**	**-**	**<0.09**	**4.3**	**-**	**0.48**	**0.21**	**0.18**	**0.76**
Lobster	SCA (north) - Early	54	-	-	45	<0.15	0.51	0.03	0.08	0.56
	SCA (north) - Late	44	-	-	15	<0.18	0.60	0.07	0.16	0.72
	SCA (north) Average	49	-	-	30	<0.17	0.56	0.05	0.12	0.64
	SCA (south) - Early	64	-	-	48	<0.15	0.67	0.02	0.10	0.64
	SCA (south) - Late	27	-	-	14	<0.20	0.18	0.03	0.01	<0.11
	SCA (south) Average	46	-	-	31	<0.18	0.43	0.03	0.06	<0.38
	SCA Average	**47**	**-**	**-**	**31**	**<0.17**	**0.49**	**0.04**	**0.09**	**0.51**
	WL – Early	65	-	-	51	<0.17	0.63	0.02	0.07	0.58
	WL – Late	41	-	-	32	<0.20	0.38	0.07	0.07	0.46
	WL - Average	**53**	**-**	**-**	**42**	**<0.19**	**0.51**	**0.05**	**0.07**	**0.52**
***Nephrops* (Scampi)**	SCA – Annual	47	-	0.06	-	<0.18	-	-	-	-
	SCA – Early	-	-	-	20	-	1.0	-	0.58	1.9
	SCA – Late[b]	-	-	-	12	-	0.51	-	0.25	1.0
	SCA Average	**47**	**-**	**0.06**	**16**	**<0.18**	**0.76**	**-**	**0.42**	**1.5**
	WL – Annual	49	-	0.11	-	<0.25	-	-	-	-
	WL – Early	-	-	-	22	-	1.4	-	0.93	2.9
	WL – Late[b]	-	-	-	17	-	0.46	-	0.33	1.4
	WL - Average	**49**	**-**	**0.11**	**20**	**<0.25**	**0.93**	**-**	**0.63**	**2.2**

Notes ^{14}C data include natural background; SCA – Sellafield coastal area; WL – Whitehaven Landed

Table 13. Radioactivity in seaweed, 2022

Species	Location	Mean concentration (Bq kg^{-1} wet weight)											
		Total α	Total β	$^{14}C^{a}$	^{60}Co	^{90}Sr	^{99}Tc	^{106}Ru	^{129}I	^{137}Cs	U(α)	Pu(α)	^{241}Am
Fucus vesiculosis	Nethertown	19	210	18	0.27	0.50	320	-	<0.47	2.3	5.5	7.5	3.9
	Drigg Barnscar	25	210	35	0.22	0.56	410	-	<0.57	1.8	6.4	10	4.0
	Walney Island	18	210	19	-	0.31	290	-	<0.48	1.4	7.1	5.4	2.3
Porphyra umbilicalis	St Bees	14	120	33	-	0.36	0.93	<0.50	-	1.4	0.41	3.4	6.3
	Braystones	11	150	32	-	<0.17	1.8	<0.60	-	0.89	0.40	3.1	4.4
	Sellafield	13	130	41	-	0.17	2.3	<0.53	-	0.89	0.38	2.4	4.3
	Seascale Neb	16	140	39	0.05	0.13	1.4	<0.46	-	0.93	0.42	2.9	5.0
	St. Bees - Selker (Av)	14	140	36	0.05	0.21	1.6	<0.52	-	1.0	0.40	2.9	5.0

a ^{14}C data include natural background

Fucus vesiculosus is collected because it accumulates many radionuclides (particularly technetium-99) and is sensitive to fluctuations in their concentrations in seawater. *Porphyra umbilicalis* is also collected and monitored as an indicator species particularly due to its historical exposure pathway role for ruthenium-106.

Table 14. Radioactivity in coastal samples of seawater from the Irish Sea, 2022

Location		Mean concentration (Bq l^{-1})												
		Total α	Total β	^{3}H	^{14}C	^{90}Sr	^{99}Tc	^{129}I	^{137}Cs	U(α)	^{237}Np	Pu(α)	^{241}Pu	^{241}Am
St Bees	filtrate	<2.8	8.8	<5.3	0.61	0.02	<0.03	<0.03	<0.03	0.09	<0.0004	0.002	<0.05	0.0007
	solids	0.13	0.17	-	-	0.006	-	-	0.01	0.002	0.00002	0.02	0.08	0.04
Sellafield	filtrate	<2.9	8.5	5.4	0.49	0.05	<0.03	<0.02	<0.03	0.08	<0.0004	0.003	<0.04	0.001
	solids	0.13	0.13	-	-	0.003	-	-	0.01	0.002	0.00003	0.02	0.09	0.04
Seascale Neb	filtrate	<3.0	11	4.1	<0.69	0.03	<0.02	<0.02	0.03	0.09	<0.0003	0.003	<0.05	0.001
	solids	0.19	0.19	-	-	0.005	-	-	<0.02	0.003	0.00005	0.04	0.15	0.07
Drigg Barnscar	filtrate	<3.0	9.8	<3.9	0.46	0.03	<0.03	<0.03	0.04	0.09	<0.0004	0.003	<0.04	0.001
	solids	0.09	0.14	-	-	<0.003	-	-	<0.008	0.001	0.00001	0.01	0.05	0.03

Table 15. Radioactivity in sediment from the West Cumbrian Coast, 2022

Location		Mean radionuclide concentration (Bq kg^{-1} dry weight)									
		Total α	Total β	^{60}Co	^{90}Sr	^{99}Tc	^{137}Cs	U-α	Pu-α	^{241}Pu	^{241}Am
Sand	St Bees	590	370	0.27	-	-	41	-	94	-	95
	Braystones	590	370	0.17	-	-	26	-	95	-	100
	Sellafield	490	400	0.14	-	-	35	-	92	-	97
	Seascale Neb	880	470	0.15	-	-	21	-	92	-	94
	Drigg Barnscar	460	440	0.16	-	-	16	-	69	-	76
Silt	Ravenglass Ford	1,100	820	<1.9	12	16	63	49	200	610	300
	Ravenglass Garth	450	330	<1.6	<0.84	3.5	12	28	92	270	150
	Ravenglass Opp Raven Villa	1,100	380	<1.6	9.5	14	63	51	140	510	280
	Eskmeals, R Esk south bank downstream of viaduct	1,200	690	<0.92	9.1	12	59	44	180	510	250
	Eskmeals Newbiggin Marsh	1,300	1,000	<1.3	75	25	130	49	350	990	570
	R Esk Muncaster Rd Bridge; Downstream	2,600	1,100	<1.4	50	35	250	57	460	1,400	880
	Whitehaven Outer Harbour (south)	580	510	<0.83	0.80	8.4	190	27	98	240	130
	Silt from R Calder	490	710	<1.2	4.0	3.0	57	37	95	230	90
	Silt from R Ehen	1,500	1,200	<1.7	14	11	140	69	230	610	350
	Waberthwaite	1,600	1,100	<1.3	20	19	160	59	340	1,000	570

Table 16. Mean gamma dose rates measured in air in intertidal and other coastal areas of Cumbria, 2022

Area of survey	Description	Nature of ground	N[b]	Mean dose rate (µGy h^{-1})[a]
Whitehaven Harbour (north)	outer harbour	mud/silt	4	0.14
St Bees (groynes)	groynes	pebbles/rocks	1	0.14
St Bees	Seamill Lane car park	car park	1	0.14
Coulderton	grassed areas/beach bungalows	grass banks	1	0.16
Nethertown	beach	pebbles/shingle	1	0.16
Braystones	beach	pebbles/shingle	1	0.15
Sellafield Beach	beach		1	0.14
Sellafield Dunes	dunes		1	0.13
Sellafield	pipeline 3	sand	12	0.09
Sellafield	pipeline 4	sand	12	0.10
Factory Sewer	outfall	rocks / boulders / sand / shingle	4	0.14
Seascale Beach	south of pipeline	rocks/sand	4	0.12
Drigg Beach	beach	sand	1	0.14
Ravenglass	Raven Villa	saltmarsh	1	0.12
Ravenglass	small boat area	firm silt / pebbles	1	0.14
Ravenglass	Salmon Garth (saltmarsh)	sand / firm silt	1	0.15
Eskmeals Viaduct	saltmarsh	saltmarsh	1	0.14
Newbiggin	saltmarsh	saltmarsh	4	0.16
Muncaster Road Bridge	riverbank	grass	1	0.17
Hall Waberthwaite	saltmarsh	saltmarsh turf	1	0.14

a Figures include contributions from natural background, typically 0.05 µGy h^{-1} over sandy areas and 0.07 µGy h^{-1} over silt.

b Number of observations

Table 17. Mean gamma dose rates measured in air at Sellafield site perimeter, 2022

Area of survey	Number of locations	Mean dose rate (µGy h^{-1})[a]
North	4	0.01
East	5	0.02
South	3	0.008
West	4	0.04
River Ehen	2	0.01
River Calder	12	0.002
Critical Group	1	0.04
Mean annual average	-	0.02

a Figures exclude contribution from natural background (approximately 0.06 µSv h^{-1}).

Table 18. Mean gamma dose rates measured in air in the vicinity of Sellafield, 2022

Location	Mean dose rate (µGy h^{-1})[a]
Calderbridge	0.06
Seascale	0.05
Ravenglass	0.04
Braystones	0.05
Whitehaven	0.04
Gosforth	0.05
Brow Top	0.05

a Figures include contribution from natural background (approximately 0.06 µGy h^{-1}).

Table 19. Radioactivity in air in the vicinity of Sellafield - Site Perimeter Locations, 2022

Radionuclide	Mean concentration (mBq m^{-3})				
	Calder Gate	**Met. Station**	**North Gate**	**West Ring Road**	**South Side**
Total Alpha	0.03	0.04	0.04	0.04	0.03
Total Beta	0.28	0.34	0.34	0.29	0.27
^{90}Sr	0.003	0.008	0.01	0.002	0.002
^{106}Ru	<0.04	<0.04	<0.04	<0.04	<0.03
^{125}Sb	<0.01	<0.01	<0.01	<0.01	<0.01
^{137}Cs	0.01	0.06	0.04	<0.006	<0.008
Pu(α)	0.0006	0.001	0.0007	0.0003	0.0003
^{241}Pu	<0.02	<0.02	<0.02	<0.02	<0.02
^{241}Am	0.0005	0.0006	0.0006	0.0003	0.0004
^{235}U	0.00002	0.00001	0.00002	0.00001	0.00001
^{238}U	0.0003	0.0003	0.0006	0.0003	0.0003

Table 20. Radioactivity in air in the vicinity of Sellafield - Residential Locations, 2022

Radionuclide	Mean concentration (mBq m^{-3})						
	Brow Top	***Braystones***	**Calderbridge**	**Gosforth**	**Ravenglass**	**Seascale**	**Whitehaven**
^{90}Sr	0.0002	0.0003	0.0006	0.0002	0.0004	0.0005	0.0002
^{137}Cs	<0.005	<0.005	<0.004	<0.005	<0.005	<0.005	<0.003
Pu(α)	0.00008	0.0002	<0.0002	<0.0002	0.0002	0.001	0.0001
^{241}Pu	<0.02	<0.04	<0.03	<0.03	<0.04	<0.03	<0.03
^{241}Am	0.0001	0.0002	0.00008	0.00007	0.0001	0.002	0.00009
^{235}U	0.000007	0.00001	0.000006	0.00001	0.00001	0.00002	0.000008
^{238}U	0.00009	0.0002	0.0001	0.0002	0.0002	0.0004	0.0001

Table 21. Radioactivity in milk from farms near Sellafield, 2022

Location	Mean concentration (Bq l^{-1})								
	Total α	**Total β**	^{3}H	$^{14}C^{a}$	$^{14}C^{b}$	^{90}Sr	^{129}I	^{131}I	^{137}Cs
Farm A	<0.19	41	2.3	14	<0.55	0.02	<0.01	<0.04	0.06
Farm B[c]	<0.14	43	<2.2	15	<0.58	0.02	<0.01	<0.04	<0.04
Farm C	<0.18	40	<2.4	18	<0.73	0.03	<0.01	<0.04	0.07

a Including natural background.
b Excluding natural background.
c Milk from Farm B has been used in the radiological assessment.

Table 22. Radioactivity in potatoes and rabbits from farms near Sellafield, 2022

Sample	Mean concentration (Bq kg^{-1})			
	^{3}H	$^{14}C^{a}$	$^{14}C^{b}$	^{137}Cs
Potatoes - Early	7.7	14	<0.60	0.15
Potatoes - Late	6.5	14	<0.50	0.15
Potatoes - Average	7.1	14	<0.55	0.15
Rabbit	-	-	-	3.6

a Including natural background.
b Excluding natural background.

Table 23. Radioactivity in total deposition, 2022

Location	Mean radionuclide concentration (Bq m^{-3})						
	Total α	Total β	^{3}H	^{90}Sr	^{137}Cs	Pu- α	^{241}Am
Calder Gate	20	<160	<4,700	4.2	13	0.44	0.31
Met Station	26	300	4,100	30	95	1.1	1.5
North Gate	32	1,900[a]	6,300	1,200[c]	1,000[b]	0.22	0.94
South Side	22	150	4,200	2.7	<6.0	0.23	1.1
West Ring Road	26	190	<4,300	14	16	0.68	1.6

a Total Beta is measured Monthly, the elevated Total Beta corresponds with high beta results from the inlet filter event during August – October.
b ^{137}Cs is measured quarterly, elevated ^{137}Cs is likely to correspond with elevated results from the inlet filter event.
c ^{90}Sr is measured annually, elevated ^{90}Sr is likely to correspond to the inlet filter event

Table 24. Radioactivity in grass, 2022

Location	Mean concentration (Bq kg^{-1} {wet weight})												
	Total α	Total β	^{3}H	$^{14}C^{a}$	$^{14}C^{b}$	^{90}Sr	^{99}Tc	^{106}Ru	^{125}Sb	^{134}Cs	^{137}Cs	U- α	Pu- α	^{241}Am
Calder Gate	4.0	96	6.3	28	1.2	2.2	-	-	0.52	-	4.4	0.23	0.17	0.21
Met Station	7.1	110	8.1	23	<0.90	8.4	-	-	-	-	8.7	0.14	0.27	0.14
North Gate	4.5	150	12	28	1.1	23	-	-	-	-	42	0.20	0.40	0.26
South Side	5.2	120	4.3	22	<0.83	0.72	-	-	-	-	0.97	0.29	0.06	0.09
West Ring Rd	2.2	95	<5.9	21	<0.83	1.2	-	-	-	-	2.4	0.22	0.19	0.20

a ^{14}C data includes background.

b Excluding natural background calculated assuming 218 Bq natural ^{14}C per kg carbon.

Table 25. Radioactivity in soil, 2022

Location	Mean concentration (Bq kg^{-1} {wet weight})											
	Total α	Total β	^{3}H	$^{14}C^{a}$	$^{14}C^{b}$	^{90}Sr	^{106}Ru	^{125}Sb	^{134}Cs	^{137}Cs	U- α	Pu- α	^{241}Am
Calder Gate	840	630	<3.5	5.5	1.5	3.0	-	-	-	60	58	29	17
Met Station	720	590	4.5	5.8	0.71	13	-	-	-	200	65	86	45
North Gate	810	690	4.3	5.0	1.4	21	-	-	-	190	63	130	31
South Side	720	910	2.8	11	<0.50	1.8	-	-	-	47	73	13	6.3
West Ring Road	680	680	2.0	5.2	<0.20	4.6	-	-	-	68	84	44	32

a ^{14}C data includes background.

b Excluding natural background calculated assuming 218 Bq natural ^{14}C per kg carbon.

Table 26. Radioactivity in local waters, 2022

Location		Mean concentration (Bq l^{-1})							
		Total α	Total β	^{3}H	^{90}Sr	^{99}Tc	^{137}Cs	Pu(α)	Am+Cm
River water:	R. Calder at Sellafield	<0.01	0.27	<4.5	0.10	<0.03	<0.005	<0.001	-
	R. Calder at Calderbridge	<0.01	<0.10	<4.0	0.003	<0.03	<0.005	<0.001	-
	R. Ehen, 5m upstream of Factory Sewer outfall	<0.02	0.21	4.5	0.004	0.03	<0.006	<0.001	-
	R. Ehen, 100m north of pipeline	<0.01	0.11	<4.6	0.003	<0.03	<0.005	<0.001	-
Lake water:	Ennerdale Water	<0.01	<0.12	<4.9	0.002	-	<0.005	<0.002	-
Tap water:	Calderbridge	<0.02	<0.09	<3.6	0.001	-	<0.005	-	-
	Sellafield	<0.01	<0.08	<3.7	0.001	-	<0.005	-	-
	Ravenglass	<0.01	<0.08	<4.6	0.001	-	<0.005	-	-
	Seascale	0.01	<0.08	<3.6	0.001	-	<0.005	-	-
	Whitehaven	<0.02	<0.08	<4.7	0.001	-	<0.006	-	-
Spring water:	Sellafield Beach (South)[a]	-	-	73	1.0	2.1	0.64	0.04	0.15
	Sellafield Beach (Maximum)[a]	-	-	520	1.0	5.6	0.64	0.04	0.15
	Sellafield Beach (Average)[a]	-	-	160	1.0	2.0	0.64	0.04	0.15

a Results corrected for seawater content.

Table 27. Non-radioactive monitoring of nitrogen dioxide in air in the vicinity of Sellafield, 2022

Location	Mean concentration (µg m^{-3})
Calder Gate	6.7
Met. Station	5.9
North Gate	6.2
West Ring Road	7.4
South Side	5.9
Air Quality Limit Value (annual mean)	*40*

Table 28. Non-radioactive monitoring of nitrate in river waters, 2022

Location	pH	Mean concentration (mg l^{-1})
River Calder - downstream of site	7.8	0.65
River Calder - upstream of site	7.6	0.62
River Ehen - upstream of Seaburn outfall	7.9	1.0
River Ehen - upstream of pipebridge	7.8	1.0
National Environmental Quality Standard	*6.0 - 9.0*	*N/A*

Table 29. Non-radioactive monitoring of coastal waters, 2022

Location	Mean concentration (mg l^{-1})	
	nitrite	nitrate
St Bees	<0.007	0.25
Sellafield	<0.007	0.15
Seascale Neb	<0.007	0.13
Drigg Barnscar	<0.007	0.09

Table 30. Non-radioactive monitoring of surface water around Calder Landfill Extension Segregated Area, 2022

Location	BOD (mg l^{-1})	COD (mg l^{-1})	TOC (mg l^{-1})	Dissolved O2 (ppm)	NH_4^+ (mg l^{-1})	SO_4^{2-} (mg l^{-1})	Conductivity (µS cm^{-1})
River Calder upstream	<1.0	4.4	2.0	11	<0.01	3.9	92
New Mill Beck upstream	<1.0	27	7.7	10	0.26	10	220
New Mill Beck overflow drain[a]	<1.2	49	17	9.8	0.36	12	220
River Calder downstream	<1.0	<5.1	1.9	11	0.02	4.6	110

a Sample only available under flood conditions.
BOD – Biological Oxygen Demand; COD – Chemical Oxygen Demand; TOC – Total Organic Carbon.

Table 31. Non-radioactive monitoring of gases on Sellafield's landfill sites, 2022

Gas spike probe monitoring	Mean concentration (% volume)		
	CH_4	CO_2	O_2
Calder Landfill Complex Boreholes	0.09	1.4	19
Calder Landfill Complex Probes	0.04	1.0	20

Beach Monitoring Data

Table 32. Beach monitoring conducted during 2022

Programme	Planned monitoring (ha)	Actual monitoring(ha)
Sellafield	52	55
Northern Beaches	32	35
Southern Beaches	16	22
Allonby	5	5
Total	**105**	**117**

Table 33. Particle and larger object beach finds recovered during 2022

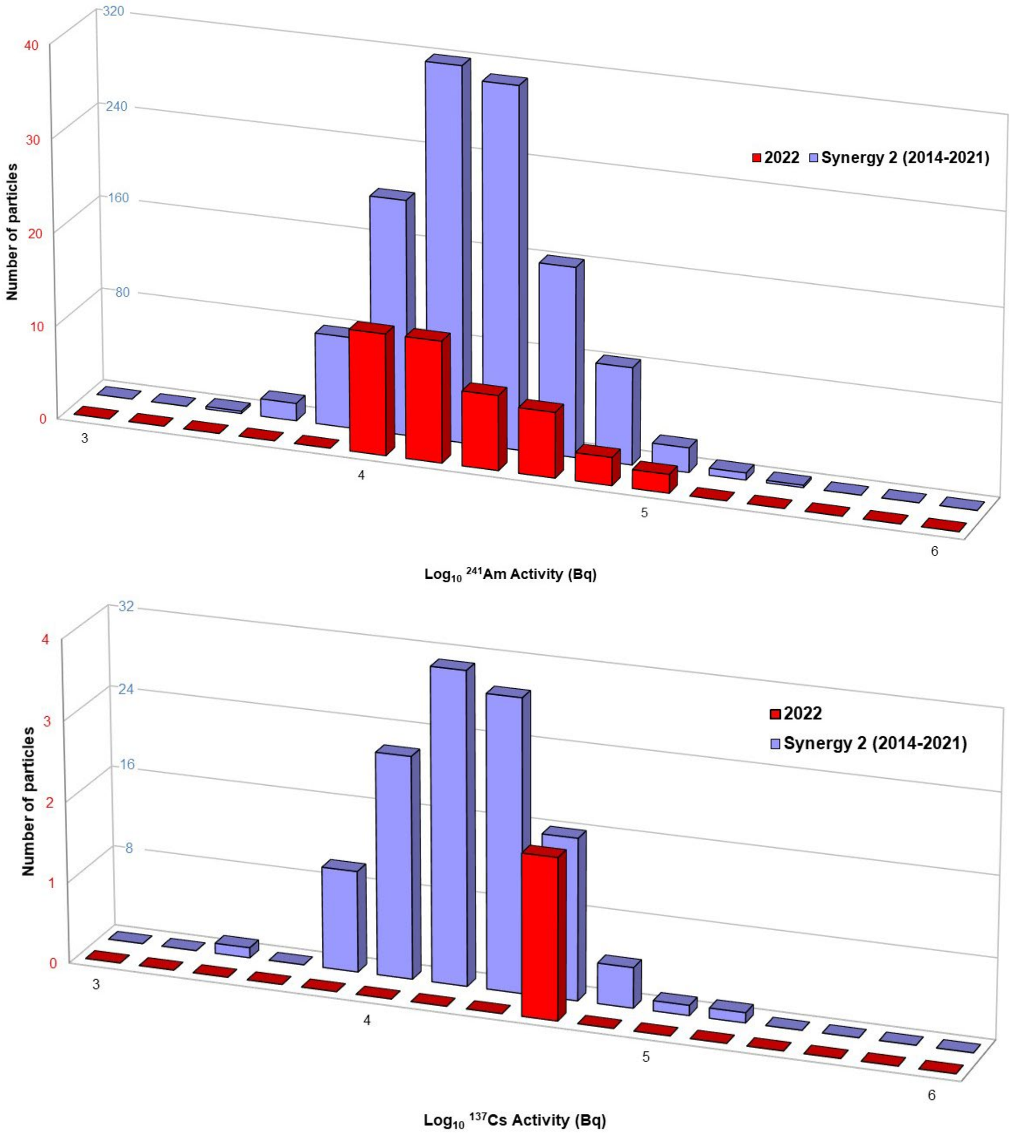
Programme	No. of particles found			No. of larger objects found			Total finds
	Alpha rich	Beta rich	Other	Alpha rich	Beta rich	Other	
Sellafield	30	2	1	0	7	0	40
Northern Beaches	11	0	0	0	0	0	11
Southern Beaches	5	0	0	0	0	0	5
Allonby	0	0	0	0	0	0	0
Total	**46**	**2**	**1**	**0**	**7**	**0**	**56**

Particles are less than 2 mm in size; Larger objects are greater than 2 mm in size; "Alpha rich", higher americium-241 activity than caesium-137 activity; "Beta rich", where caesium-137 was the major radionuclide; "other" denotes the principal radionuclide is neither americium-241 activity or caesium-137, for example cobalt-60

Table 34. Total area monitored and finds by category, beach and calendar year (2018 - 2022)

Beach	Year	Area (ha)	Alpha rich particle	Beta rich particle	Beta rich larger object	Other finds
Sellafield	2018	81	88	6	17	0
	2019	81	74	5	6	0
	2020	58	48	4	2	0
	2021	57	24	1	4	0
	2022	55	30	2	7	1
Northern Beaches	2018	44	22	1	0	0
	2019	42	31	0	0	0
	2020	30	19	0	0	0
	2021	36	68	0	0	0
	2022	35	11	0	0	0
Southern Beaches	2018	25	10	0	0	0
	2019	25	2	0	0	0
	2020	19	1	0	0	0
	2021	24	1	0	0	0
	2022	22	5	0	0	0
Allonby	2018	10	1	0	0	0
	2019	10	1	0	0	0
	2020	6	0	0	0	0
	2021	5	0	0	0	0
	2022	5	0	0	0	0

Figure 4. Radioactivity of finds classified as alpha-rich particles (upper) and beta rich particles (lower) between 2014 – 2021 (shown in blue) compared to data from 2022 shown in red)



RIFE data used in the Radiological Dose Assessment

Table 35. Radioactivity in animal produce from farms near Sellafield, 2021 (data From RIFE27)

Species	**Mean concentration (Bq kg^{-1} {wet weight})[a]**														
	^{3}H[b]	**^{14}C[b]**	**^{14}C[c]**	**^{60}Co**	**^{90}Sr**	**^{99}Tc**	**^{106}Ru**	**^{125}Sb**	**^{129}I**	**^{134}Cs**	**^{137}Cs**	**^{238}Pu**	**$^{239+240}$Pu**	**^{241}Pu**	**^{241}Am**
Bovine muscle	<2.7	46	9.0	<0.05	<0.05	<0.05	<0.41	<0.10	<0.02	<0.05	0.41	0.00004	0.0001	<0.34	0.0002
Bovine liver	<3.6	29	3.0	<0.05	<0.04	<0.05	<0.37	<0.10	<0.03	<0.05	0.23	0.0003	0.002	<0.19	0.003
Bovine kidney	<3.7	33	7.0	<0.04	<0.10	<0.04	<0.43	<0.14	<0.03	<0.05	0.34	<0.0003	0.0002	<1.5	0.001
Ovine muscle	<5.5	41	-	<0.05	<0.04	<0.04	<0.41	<0.10	<0.03	<0.04	1.0	<0.00006	0.0002	<0.38	0.0003
Ovinekidney/ liver	<13	48	22	<0.05	0.06	<0.04	<0.34	<0.09	<0.02	<0.04	0.31	0.0003	0.003	<0.42	0.003
Deer	<3.4	26	-	<0.04	<0.05	<0.08	<0.29	<0.08	<0.03	<0.04	0.41	<0.0001	0.00007	<0.35	0.0002
Duck	<4.9	41	-	<0.04	<0.04	-	<0.34	<0.10	<0.02	<0.06	0.10	<0.00007	0.0001	<0.42	0.0002
Pheasant	<6.4	46	14	<0.06	<0.04	<0.05	<0.46	<0.17	<0.04	<0.08	0.15	0.00004	0.00006	<0.68	0.0002
Wild wood pigeon	<6.8	46	14	<0.07	<0.04	-	<0.55	<0.13	<0.03	<0.06	0.44	0.00003	0.0001	<0.34	0.00005
Rabbit	<3.5	24	-	<0.04	0.04	<0.08	<0.30	<0.09	<0.03	<0.02	0.07	<0.00007	<0.0001	<0.25	0.00004
Eggs - Chicken	<5.7	37	5.0	<0.04	<0.03	-	<0.37	<0.10	<0.04	<0.03	<0.04	<0.0001	<0.0001	<0.59	0.00007

a Values shown in pale blue boxes are from measurements performed by the FSA.

b Including natural background.

c Excluding natural background (values taken from RIFE). Measured concentrations that are smaller than background value are indicated by a hyphen.

Table 36. Radioactivity in fruit and vegetable produce collected near Sellafield, 2022 (Data From RIFE27)

Species	**Mean concentration (Bq kg^{-1} {wet weight})[a]**														
	^{3}H[b]	**^{14}C[b]**	**^{14}C[c]**	**^{60}Co**	**^{90}Sr**	**^{99}Tc**	**^{106}Ru**	**^{125}Sb**	**^{129}I**	**^{134}Cs**	**^{137}Cs**	**^{238}Pu**	**$^{239+240}$Pu**	**^{241}Pu**	**^{241}Am**
Potato	-	-	-	<0.07	<0.04	-		<0.12	<0.03	<0.06		0.0001	0.001	-	0.002
Cabbage	<2.0	5.8	-	<0.06	0.04	-	<0.43	<0.12	<0.03	<0.03	<0.05	<0.00008	0.00008	-	0.0001
Broccoli	<2.6	17	10.0	<0.07	<0.06	-	<0.55	<0.09	<0.02	<0.07	<0.06	<0.0001	<0.0002	-	0.0001
Cauliflower[d]	<2.1	9.2	2.2	<0.10	-	-	<0.68	<0.16	<0.04	<0.07	<0.07	-	-	-	-
Carrots	<2.0	11	4.3	<0.07	0.02	-	<0.54	<0.14	<0.03	<0.08	0.08	-	-	-	-
Beetroot	<2.1	3.0	-	<0.03	0.06	<0.05	<0.25	<0.07	<0.02	<0.04	0.11	-	-	-	-
Onion	-	14	7.0	<0.06	0.20	-	<0.29	<0.10	<0.04	<0.05	0.07	-	-	-	-
Runner beans[d]	<2.0	17	-	<0.06	0.33	-	<0.52	<0.11	<0.06	<0.06	<0.06	<0.0001	0.0003	-	0.0007
Mushroom	<2.1	8.5	4.5	<0.03	0.02	-	<0.26	<0.07	<0.03	<0.03	4.3	0.005	0.04	0.20	0.06
Apple	<2.5	16	8.1	<0.02	0.10	<0.05	<0.21	<0.05	<0.03	<0.04	0.35	<0.00009	0.0002	-	0.0003
Blackcurrants[d]	<4.0	17	9.0	<0.20	0.08	-	<1.2	<0.30	<0.02	-	0.11	0.0002	0.0005	-	0.002
Strawberries[d]	<2.0	15	7.0	<0.06	0.14	-	<0.64	<0.16	<0.05	<0.07	<0.06	<0.0001	<0.0003	-	<0.0002
Blackberries	<2.0	17	9.0	<0.02	0.09	-	<0.21	<0.06	<0.03	<0.02	<0.04	<0.0001	0.0002	-	0.0003
Elderberries[d]	<2.0	26	18.0	<0.11	0.04	-	<0.52	<0.18	<0.08	<0.08	0.14	0.001	0.004	-	0.008
Honey[d]	-	78	11.0	<0.02	<0.04	-	<0.31	<0.08	<0.02	<0.03	<0.06	<0.0002	<0.0002	-	0.0001
Swede[d]	-	5.4	-	<0.06	0.05	-	<0.47	<0.13	<0.02	<0.06	<0.06	-	-	-	-

a Values shown in pale blue boxes are from measurements performed by the FSA.
b Including natural background.
c Excluding natural background (values taken from RIFE). Measured concentrations that are smaller than background value are indicated by a hyphen.
d Year sampled - cauliflower (2013); runner beans (2013); blackcurrants (2012); strawberries (2013); elderberries (2013); honey (2014); swede (2017)

Radiological Dose Assessment Data Tables

The radiological dose assessment presented herein takes account of research studies carried out both nationally and internationally. In addition, the guidance of UKHSA, the National Dose Assessment Working Group (NDAWG) and the most recent dose coefficients in the International Commission for Radiological Protection (ICRP) Publication 119 are adopted where available and appropriate. In general, default values recommended by the ICRP for each radionuclide are assumed for the purpose of dose calculations unless specific studies indicate that an alternative is appropriate.

Table 37. Summary of doses associated with seafood (µSv), 2022

Radionuclide	Cod				Plaice				Lobsters				Crabs			
	Adult	Child	Infant	Foetus	Adult	Child	Infant	Foetus	Adult	Child	Infant	Foetus	Adult	Child	Infant	Foetus
Carbon-14[a]	0.11	0.03	0.01	0.15	0.29	0.08	0.04	0.41	0.20	0.06	0.03	0.28	0.24	0.07	0.03	0.33
Cobalt-60	-	-	-	-	-	-	-	-	-	-	-	-	0.007	0.004	0.003	0.004
Strontium-90	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.01	0.004	0.04
Technetium-99	0.003	0.001	0.001	0.002	0.03	0.01	0.01	0.02	0.30	0.12	0.11	0.22	0.03	0.01	0.01	0.02
Ruthenium-106	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iodine-129	-	-	-	-	-	-	-	-	0.28	0.10	0.03	0.11	-	-	-	-
Caesium-137	0.54	0.08	0.02	0.24	0.34	0.05	0.02	0.15	0.10	0.01	0.004	0.04	0.06	0.009	0.003	0.02
Neptunium-237	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plutonium-alpha	0.01	0.003	0.001	0.0005	0.05	0.01	0.004	0.002	0.34	0.07	0.03	0.01	0.46	0.10	0.04	0.02
Plutonium-241	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Americium-241	0.01	0.003	0.001	0.0002	0.04	0.008	0.003	0.0005	1.5	0.34	0.14	0.02	1.5	0.33	0.14	0.02
Curium-alpha	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.68	0.12	0.04	0.39	0.75	0.16	0.07	0.58	2.8	0.70	0.34	0.68	2.3	0.53	0.23	0.46

Radionuclide	Nephrops				Winkles				Mussels				Total			
	Adult	Child	Infant	Foetus	Adult	Child	Infant	Foetus	Adult	Child	Infant	Foetus	Adult	Child	Infant	Foetus
Carbon-14[a]	0.09	0.02	0.01	0.12	0.13	0.04	0.02	0.18	0.10	0.03	0.01	0.14	1.2	0.33	0.15	1.6
Cobalt-60	-	-	-	-	0.009	0.006	0.004	0.005	0.004	0.003	0.002	0.002	0.02	0.01	0.009	0.01
Strontium-90	0.01	0.005	0.002	0.02	0.17	0.07	0.03	0.26	0.03	0.01	0.005	0.05	0.23	0.10	0.04	0.37
Technetium-99	0.07	0.03	0.03	0.05	0.12	0.05	0.05	0.09	0.04	0.01	0.01	0.03	0.59	0.23	0.22	0.43
Ruthenium-106	-	-	-	-	0.04	0.02	0.01	0.002	0.03	0.01	0.009	0.001	0.07	0.03	0.02	0.003
Iodine-129	0.13	0.05	0.01	0.05	0.10	0.03	0.01	0.04	-	-	-	-	0.51	0.18	0.05	0.20
Caesium-137	0.07	0.01	0.003	0.03	0.25	0.04	0.01	0.11	0.05	0.008	0.003	0.02	1.4	0.21	0.06	0.61
Neptunium-237	-	-	-	-	0.006	0.001	0.0006	0.0002	-	-	-	-	0.006	0.001	0.0006	0.0002
Plutonium-alpha	0.70	0.15	0.06	0.03	4.2	0.91	0.35	0.16	2.8	0.61	0.24	0.11	8.6	1.9	0.73	0.33
Plutonium-241	-	-	-	-	0.26	0.06	0.02	0.006	0.18	0.04	0.01	0.004	0.44	0.10	0.03	0.01
Americium-241	2.0	0.44	0.19	0.03	5.8	1.3	0.53	0.08	4.2	0.92	0.39	0.06	15	3.3	1.4	0.21
Curium-alpha	-	-	-	-	0.05	0.01	0.006	0.05	-	-	-	-	0.05	0.01	0.006	0.05
Total	3.1	0.71	0.30	0.33	11	2.5	1.0	0.98	7.4	1.6	0.68	0.41	28	6.3	2.7	3.8

Background corrected values for carbon-14 in fish, molluscs and crustaceans have been used in the assessment of radiation doses to critical groups. For these marine foodstuffs, the natural concentration of carbon-14 of 218 Bq carbon-14 per kg carbon has been taken from data published by the EA and FSA.

Table 38. Summary of doses to terrestrial critical group from terrestrial foodstuffs and inhalation (µSv), 2022

Radionuclide	Milk				Beef Muscle				Beef Offal				Sheep Muscle			
	Adult	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**
Total tritium	0.01	0.02	0.04	0.01	0.002	0.002	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	0.002	0.001	<0.001	0.003
Carbon-14[a]	0.04	0.06	0.15	0.06	0.08	0.11	0.04	0.11	0.008	0.006	0.004	0.01	-	-	-	-
Cobalt-60	-	-	-	-	0.003	0.008	0.004	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001	<0.001
Strontium-90	0.09	0.22	0.36	0.13	0.02	0.05	0.01	0.03	0.006	0.007	0.003	0.009	0.01	0.01	0.003	0.01
Technetium-99	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ruthenium-106[b]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony-125	-	-	-	-	0.002	0.003	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iodine-129	0.10	0.21	0.29	0.04	0.03	0.06	0.01	0.01	0.009	0.009	0.003	0.004	0.03	0.02	0.005	0.01
Iodine-131	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caesium-134	-	-	-	-	0.01	0.01	0.002	0.007	0.003	0.001	<0.001	0.001	0.006	0.002	<0.001	0.003
Caesium-137	0.09	0.08	0.11	0.04	0.08	0.06	0.01	0.04	0.01	0.004	0.002	0.004	0.10	0.04	0.01	0.05
Plutonium-alpha	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Plutonium-241	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Americium-241	-	-	-	-	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total	0.33	0.59	0.95	0.28	0.23	0.31	0.08	0.21	0.04	0.03	0.02	0.04	0.15	0.08	0.03	0.08

Radionuclide	Sheep offal				Poultry				Eggs				Game			
	Adult	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**
Total tritium	0.002	0.001	<0.001	0.002	0.002	0.002	0.001	0.003	0.002	0.002	0.003	0.003	0.001	0.001	<0.001	0.002
Carbon-14[a]	0.04	0.03	0.02	0.05	-	-	-	-	0.02	0.03	0.04	0.03	0.02	0.01	0.006	0.02
Cobalt-60	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.002	<0.001	0.001	0.003	0.005	<0.001	<0.001	0.002	0.001	<0.001
Strontium-90	0.005	0.006	0.003	0.008	0.01	0.01	0.007	0.02	0.008	0.01	0.01	0.01	0.008	0.01	0.003	0.01
Technetium-99	<0.001	<0.001	<0.001	<0.001	-	-	-	-	-	-	-	-	<0.001	<0.001	<0.001	<0.001
Ruthenium-106[b]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony-125	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	<0.001	<0.001	0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001
Iodine-129	0.006	0.006	0.002	0.002	0.02	0.02	0.009	0.009	0.04	0.05	0.04	0.01	0.02	0.03	0.006	0.009
Iodine-131	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caesium-134	0.002	<0.001	<0.001	<0.001	0.01	0.005	0.002	0.005	0.005	0.003	0.002	0.002	0.005	0.003	<0.001	0.002
Caesium-137	0.01	0.005	0.002	0.005	0.01	0.006	0.002	0.006	0.004	0.003	0.002	0.002	0.02	0.008	0.002	0.007
Plutonium-alpha	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Plutonium-241	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Americium-241	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total	0.07	0.06	0.04	0.07	0.06	0.05	0.03	0.05	0.08	0.11	0.11	0.06	0.08	0.07	0.03	0.06

Radionuclide	Honey				Mushroom				Potato				Root veg.			
	Adult	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**
Total tritium	-	-	-	-	<0.001	<0.001	<0.001	<0.001	0.04	0.03	0.03	0.05	<0.001	<0.001	0.001	0.001
Carbon-14[a]	0.02	0.02	0.04	0.02	0.008	0.005	0.004	0.01	0.04	0.04	0.03	0.05	0.02	0.02	0.03	0.03
Cobalt-60	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.03	0.07	0.07	0.02	0.002	0.004	0.007	0.001
Strontium-90	0.003	0.005	0.007	0.005	0.002	0.002	0.001	0.003	0.15	0.22	0.13	0.22	0.03	0.04	0.04	0.04
Technetium-99	-	-	-	-	-	-	-	-	-	-	-	-	<0.001	<0.001	0.001	<0.001
Ruthenium-106[b]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony-125	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.02	0.02	0.03	0.007	0.001	0.001	0.003	<0.001
Iodine-129	0.006	0.008	0.009	0.002	0.01	0.009	0.004	0.004	0.40	0.48	0.23	0.16	0.03	0.03	0.03	0.01
Iodine-131	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caesium-134	0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.14	0.07	0.03	0.06	0.01	0.005	0.005	0.005
Caesium-137	0.002	0.001	0.001	<0.001	0.17	0.06	0.03	0.07	0.23	0.13	0.06	0.10	0.01	0.005	0.005	0.005
Plutonium-alpha	<0.001	<0.001	<0.001	<0.001	0.03	0.02	0.01	0.001	0.03	0.02	0.02	0.001	-	-	-	-
Plutonium-241	-	-	-	-	0.003	0.002	<0.001	<0.001	-	-	-	-	-	-	-	-
Americium-241	<0.001	<0.001	<0.001	<0.001	0.04	0.02	0.01	<0.001	0.05	0.04	0.03	<0.001	-	-	-	-
Total	0.04	0.04	0.06	0.03	0.27	0.12	0.07	0.10	1.1	1.1	0.66	0.67	0.11	0.11	0.12	0.10

Radionuclide	Green veg.				Domestic Fruit				Wild Fruit				Legumes			
	Adult	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**	**Adult**	**Child**	**Infant**	**Foetus**
Total tritium	0.001	<0.001	<0.001	0.002	0.009	0.008	0.01	0.01	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.003
Carbon-14[a]	0.04	0.02	0.02	0.05	0.35	0.32	0.45	0.48	0.05	0.03	0.02	0.08	-	-	-	-
Cobalt-60	0.004	0.005	0.007	0.002	0.02	0.05	0.09	0.01	0.002	0.002	0.002	<0.001	0.004	0.005	0.005	0.002
Strontium-90	0.02	0.02	0.02	0.03	0.25	0.35	0.35	0.37	0.01	0.01	0.006	0.02	0.20	0.17	0.09	0.30
Technetium-99	-	-	-	-	0.002	0.003	0.008	0.002	-	-	-	-	-	-	-	-
Ruthenium-106[b]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony-125	0.002	0.002	0.003	<0.001	0.01	0.02	0.04	0.006	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.002	0.001
Iodine-129	0.05	0.03	0.02	0.02	0.28	0.32	0.26	0.11	0.04	0.03	0.01	0.02	0.13	0.09	0.04	0.05
Iodine-131	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caesium-134	0.02	0.005	0.003	0.007	0.08	0.04	0.03	0.04	0.007	0.002	<0.001	0.003	0.02	0.007	0.003	0.01
Caesium-137	0.01	0.004	0.003	0.005	0.17	0.09	0.07	0.07	0.008	0.003	0.001	0.004	0.02	0.005	0.002	0.007
Plutonium-alpha	<0.001	<0.001	<0.001	<0.001	0.008	0.006	0.007	<0.001	0.005	0.002	0.001	<0.001	0.002	<0.001	<0.001	<0.001
Plutonium-241	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Americium-241	<0.001	<0.001	<0.001	<0.001	0.01	0.009	0.01	<0.001	0.006	0.003	0.002	<0.001	0.003	0.001	<0.001	<0.001
Total	0.15	0.09	0.08	0.12	1.2	1.2	1.3	1.1	0.13	0.09	0.05	0.13	0.38	0.28	0.15	0.38

Table 38. Summary of doses to terrestrial critical group from terrestrial foodstuffs and inhalation (µSv)[a], 2022 Cont.

Radionuclide	Drinking water				Inhalation				Total dose			
	Adult	Child	Infant	Foetus	Adult	Child	Infant	Foetus	Adult	Child	Infant	Foetus
Total tritium	0.10	0.08	0.12	0.14	-	-	-	-	0.18	0.15	0.22	0.25
Carbon-14[b]	-	-	-	-	-	-	-	-	0.74	0.70	0.85	1.00
Cobalt-60	-	-	-	-	-	-	-	-	0.07	0.16	0.20	0.05
Strontium-90	0.03	0.04	0.04	0.05	0.001	0.001	<0.001	<0.001	0.84	1.2	1.1	1.2
Technetium-99	-	-	-	-	-	-	-	-	0.008	0.009	0.01	0.008
Ruthenium-106[c]	-	-	-	-	0.01	0.009	0.008	<0.001	0.03	0.03	0.02	0.02
Antimony-125	-	-	-	-	<0.001	<0.001	<0.001	<0.001	0.05	0.06	0.09	0.03
Iodine-129	-	-	-	-	-	-	-	-	1.2	1.4	0.97	0.47
Iodine-131	-	-	-	-	-	-	-	-	<0.001	<0.001	<0.001	<0.001
Caesium-134	-	-	-	-	<0.001	<0.001	<0.001	<0.001	0.32	0.16	0.08	0.15
Caesium-137	0.04	0.02	0.02	0.02	<0.001	<0.001	<0.001	<0.001	0.99	0.53	0.33	0.44
Plutonium-alpha	0.13	0.08	0.09	0.005	0.18	0.10	0.05	0.003	0.33	0.19	0.12	0.02
Plutonium-241	-	-	-	-	0.18	0.09	0.04	0.002	0.18	0.09	0.04	0.003
Americium-241	<0.001	<0.001	<0.001	<0.001	0.15	0.08	0.05	<0.001	0.29	0.17	0.11	0.02
Total	0.30	0.22	0.27	0.22	0.52	0.28	0.15	0.01	5.18	4.77	4.12	3.69

a Calculated using background corrected activity concentrations (see Monitoring chapter).
b Derived from standard modelling techniques.

Doses determined from RIFE data (Tables 35 and 36) are shaded
Doses assessed as being less than 0.001 µSv have been presented as "<0.001".
Foodstuff consumption rates used for 2022 are summarised later in this section. The two food groups assigned "high consumption rates" in 2022 were domestic fruit and potatoes.
The doses from ruthenium-106 in all terrestrial foodstuffs were assessed using standard modelling techniques. These are based on knowledge of the transfer of these radionuclides through the food chain. This is considered to be more realistic than using the limits of detection from the radiochemical analysis.

Table 39. Modelled concentrations of Ru-106 in terrestrial foodstuffs (Bq kg^{-1} or Bq l^{-1}) in 2022

Milk	Beef	Mutton	Liver	Green Veg.	Root Veg.	Fruit	Poultry	Eggs
2.37E-07	1.28E-04	1.86E-04	1.86E-04	8.12E-04	7.34E-06	7.09E-05	5.91E-08	5.06E-08

Table 40. Summary of doses to the terrestrial critical group from seafood consumption (µSv) in 2022

Radionuclide	Adult	Child	Infant	Foetus
Carbon-14[a]	0.13	0.03	0.02	0.17
Technetium-99	0.01	0.004	0.004	0.007
Caesium-137	0.37	0.06	0.02	0.16
Plutonium-alpha	0.02	0.005	0.002	0.0009
Americium-241	0.02	0.004	0.002	0.0003
Total	0.55	0.11	0.04	0.35

a Calculated using background corrected activity concentrations

Table 41. Summary of doses to the terrestrial critical group (µSv), 2022

Pathway	Adult	Child	Infant	Foetus
Terrestrial food consumption	4.6	4.5	4.0	3.7
Marine food consumption	0.55	0.11	0.04	0.35
Inhalation	0.60	0.32	0.17	0.01
Immersion (krypton-85)[a]	0.005	0.004	0.004	0.005
External (beach)	2.9	1.4	0.09	2.9
Total	8.6	6.4	4.3	7.0

a Kr-85 doses were determined using modelling and dosimetry data published by the EU and the ICRP.

Table 42. Critical group doses from operations at Sellafield (μSv)

Pathway	**2021**	**2022**
Marine critical group (adults)		
seafood consumption	24	28
aerial pathways	1.5	1.6
external radiation from beach occupancy (marine)	35	42
Total dose to marine critical group (adults)	**60**	**72**
Terrestrial critical group (adults)		
inhalation	0.52	0.6
immersion	0.03	0.005
external radiation from beach occupancy (terrestrial)	2.9	2.9
terrestrial foodstuff consumption	4.7	4.6
marine foodstuff consumption	0.58	0.55
direct radiation	2.9	3.0
Total dose to terrestrial critical group (adults)	**12**	**12**

Table 43. Collective doses from Sellafield's discharges, 2022

Radionuclide	**Collective Dose (manSv)**					
	Aerial Discharges			**Marine Discharges**		
	UK	**Europe**	**World**	**UK**	**Europe**	**World**
Tritium	0.01	0.02	0.02	0.00006	0.0002	0.005
Carbon-14	0.02	0.09	1.1	0.17	0.56	5.8
Krypton-85	0.01	0.04	0.63	-	-	-
Technetium-99	-	-	-	0.0009	0.003	0.003
Iodine-129	0.08	0.38	0.54	0.0003	0.0009	0.004
Caesium-137	0.001	0.005	0.005	0.02	0.06	0.10
Plutonium-alpha	0.009	0.01	0.01	0.02	0.06	0.07
Americium-241	0.001	0.002	0.002	0.01	0.04	0.04
Other nuclides	0.0002	0.0004	0.0004	0.02	0.07	0.07
Total	0.13	0.55	2.3	0.25	0.78	6.0

Collective doses have been calculated, using a 500 year integration period, based on the most recent European Union (EU) methodology.

Representative Persons Dose Assessment

Table 44. Summary of representative person dose calculations for various age groups. 2022. Highlighted entries denote top two dose contribution pathways per age and source category.

Pathway	Adult Dose (microSv)			Child Dose (microSv)			Infant Dose (microSv)		
	Total	Marine	Terrestrial	Total	Marine	Terrestrial	Total	Marine	Terrestrial
Crustacean Consumers	10.7	9.8	0.9	4.5	3.6	0.9	1.7	0.8	0.9
Occupants for Direct Radiation	6.7	3.4	3.3	4.9	1.6	3.3	3.4	0.1	3.3
Egg Consumers	2.3	0.2	2.1	2.1	0.1	1.9	2.1	0.0	2.1
Freshwater Fish Consumers	1.6	0.0	1.6	1.5	0.0	1.5	1.1	0.0	1.1
Sea Fish Consumers	11.5	11.1	0.4	5.2	4.8	0.4	1.0	0.5	0.4
Domestic Fruit Consumers	6.4	3.5	2.9	4.6	1.7	2.9	3.7	0.1	3.6
Wild Fruit and Nut Consumers	2.3	0.4	1.9	1.9	0.1	1.8	1.9	0.0	1.8
Occupants over Saltmarsh	30.5	30.5	0.0	15.2	15.2	0.0	0.9	0.9	0.0
Occupants over Sediment	41.1	40.7	0.4	20.6	20.2	0.4	1.7	1.3	0.4
Honey Consumers	1.6	0.0	1.6	1.5	0.0	1.5	1.1	0.0	1.1
Marine Plants and Algae	15.2	15.2	0.0	7.3	7.3	0.0	0.6	0.6	0.0
Cattle Meat Consumers	2.6	0.1	2.5	2.4	0.1	2.3	2.0	0.0	2.0
Game Meat Consumers	2.9	1.3	1.5	1.4	0.4	1.0	0.7	0.2	0.6
Poultry Meat Consumers	21.7	18.9	2.7	11.8	9.4	2.4	2.9	0.6	2.3
Sheep Meat Consumers	2.6	0.0	2.6	2.3	0.0	2.2	2.1	0.0	2.1
Wildfowl Consumers	1.7	0.9	0.8	1.0	0.5	0.6	0.4	0.0	0.4
Milk Consumers	1.2	0.1	1.2	1.4	0.0	1.4	2.0	0.0	2.0
Mollusc Consumers	48.1	48.1	0.0	17.9	17.9	0.0	3.1	3.1	0.0
Mushroom Consumers	3.4	0.8	2.7	2.9	0.4	2.5	2.5	0.0	2.5
Occupants In Water	1.3	1.3	0.0	0.6	0.6	0.0	0.0	0.0	0.0
Occupants On Water	2.3	2.3	0.0	0.7	0.7	0.0	0.3	0.3	0.0
Local Inhabitants (0 - 0.25km)	4.7	0.2	4.5	4.4	0.1	4.3	4.1	0.0	4.1
Local Inhabitants (0.25 - 0.5km)	5.0	0.0	5.0	4.6	0.0	4.6	4.5	0.0	4.5
Local Inhabitants (0.5 - 1km)	5.3	1.5	3.8	4.5	0.7	3.8	3.8	0.0	3.7
Green Vegetable Consumers	10.0	6.3	3.7	6.6	3.1	3.5	3.8	0.2	3.6
Other Domestic Vegetable	10.2	6.8	3.4	6.7	3.4	3.3	3.6	0.2	3.4
Potato Consumers	2.3	0.0	2.3	2.3	0.0	2.3	2.1	0.0	2.1
Root Vegetable Consumers	10.2	6.3	3.9	6.9	3.1	3.7	4.2	0.2	4.0

Dosimetric considerations for individual and collective doses

Data identifying critical groups and their habits by pathway have been provided by the FSA, EA and the Centre for Environment, Fisheries and Aquaculture Science (Cefas), or their predecessors, based on published survey work.

Worked example of committed effective dose calculation for an individual member of a critical group

Table 45 CED received by an adult member of the seafood consuming critical group from Am-241 in winkles

	Parameter	**Value**	**Location in report**
A	Am-241 activity concentration in winkles	12 Bq kg^{-1}	Table 11
B	Consumption rate of winkles by adults	6 kg y^{-1}	Table 46
C	Committed effective dose per unit intake value for ingestion for Am-241 in Cumbrian winkle consumed by an adult	8.0E-08 Sv Bq^{-1}	Table 49

CED received by an adult member of the seafood consuming critical group from Am-241 in winkles is:
CED = A x B x C in units of Sv per year;
CED = 12 Bq kg^{-1} x 6 kg y^{-1} x 8.0E-08 Sv Bq^{-1} = 5.8E-06 Sv y^{-1},

This approach is repeated for all radionuclides of interest in each seafood species of interest, through the incorporation of the appropriate consumption rates and committed effective dose per unit intake values.

Care is needed in using the correct dose per unit intake values for Cumbrian winkles as a specific set of data for transuranic radionuclides are available.

Table 46. Seafood consumption rates from people associated with marine discharges (2017 – 2021 average data)

Seafood	**Consumption rates (kg y^{-1}) (2017 – 2021 average)**		
	Critical group (Sellafield fishing community)[a]	**Consumers associated with Whitehaven fishery[b]**	**Typical seafood consumers (Whitehaven)[b]**
Fish:			
Cod	15.4	20	7.5
Plaice	27.4	20	7.5
Crustacea:			
Crabs	9.7	0	0
Lobsters	15.1	0	0
Nephrops	6.7	9.7	0
Molluscs:			
Winkles	6.0	0	0
Mussels	5.1	0	0

a CEFAS, 2022. Radiological Habits Survey: Sellafield, 2021.
b RIFE-27.

Table 47. Consumption rates of critical group consumers associated with aerial discharges

Foodstuff[a]	**Consumption rate (kg y^{-1})[bc]**		
	Adult	**Child**	**Infant**
milk	95	110	130
beef	15	15	3
beef liver	2.75	1.5	0.5
mutton	8	4	0.8
poultry	10	5.5	2
game	6	4	0.8
fish (cod + plaice)	15	3	0.75
leafy vegetables	15	6	3.5
potatoes	**120**	**85**	**35**
root vegetables	10	6	5
legumes	20	8	3
domestic fruit	**75**	**50**	**35**
wild fruit	7	3	1
mushrooms	3	1.5	0.6
honey	2.5	2	2
eggs	8.5	6.5	5

a Based on UKHSA and FSA recommendations.
b Consumption rates for foetal exposure taken to be same as those of adults.
c Domestic fruit and potatoes as high rate consumers

Table 48. Parameters for calculation of plume immersion and inhalation doses

	Adult	Child	Infant
Occupancy (%)	100%	100%	100%
Time Indoors (%)	50%	90%	90%
Cloud Shielding Factor	0.2	0.2	0.2
Ground Shielding Factor	0.1	0.1	0.1
Breathing rate (m^3 a^{-1})	9,860	5,600	1,900
Drinking Water (l a^{-1})	600	350	260

Foetal dose is calculated from the adult dose multiplied by the ratio of the foetus to the adult dose conversion factors.

Table 49. Committed effective doses per unit intake for ingestion

Radionuclide	f_1[a]	Dose per unit intake (Sv Bq^{-1})			
		Foetus	1 year old	10 year old	Adult
H-3 organic	1E+00	6.3E-11	1.2E-10	5.7E-11	4.2E-11
C-14	1E+00	8.0E-10	1.6E-09	8.0E-10	5.8E-10
Co-60	1E-01	1.9E-09	2.7E-08	1.1E-08	3.4E-09
Sr-90	3E-01	4.6E-08	9.3E-08	6.6E-08	3.1E-08
Zr-95	1E-02	7.6E-10	8.8E-09	3.0E-09	1.5E-09
Nb-95	1E-02	3.7E-10	3.2E-09	1.1E-09	5.8E-10
Tc-99	5E-01	4.6E-10	4.8E-09	1.3E-09	6.4E-10
Ru-106	5E-02	3.8E-10	4.9E-08	1.5E-08	7.0E-09
Ag-110m	5E-02	2.1E-09	1.4E-08	5.2E-09	2.8E-09
Sb-125	1E-01	4.7E-10	6.1E-09	2.1E-09	1.1E-09
I-129	1E+00	4.4E-08	2.2E-07	1.9E-07	1.1E-07
I-131	1E+00	2.3E-08	1.8E-07	5.2E-08	2.2E-08
Cs-134	1E+00	8.7E-09	1.6E-08	1.4E-08	1.9E-08
Cs-137	1E+00	5.7E-09	1.2E-08	1.0E-08	1.3E-08
U-234	2E-02	1.5E-08	1.3E-07	7.4E-08	4.9E-08
U-235	2E-02	1.4E-08	1.3E-07	7.1E-08	4.7E-08
U-238	2E-02	1.3E-08	1.5E-07	7.5E-08	4.8E-08
Np-237	5E-04	3.6E-09	2.1E-07	1.1E-07	1.1E-07
Pu-238	5E-04	9.0E-09	4.0E-07	2.4E-07	2.3E-07
Pu-239	5E-04	9.5E-09	4.2E-07	2.7E-07	2.5E-07
Pu-240	5E-04	9.5E-09	4.2E-07	2.7E-07	2.5E-07
Pu-241	5E-04	1.1E-10	5.7E-09	5.1E-09	4.8E-09
Am-241	5E-04	2.7E-09	3.7E-07	2.2E-07	2.0E-07
Cm-242	5E-04	4.7E-10	7.6E-08	2.4E-08	1.2E-08
Cm-243	5E-04	1.5E-07	3.3E-07	1.6E-07	1.5E-07
Cm-244	5E-04	2.2E-09	2.9E-07	1.4E-07	1.2E-07
Pu-238 (winkle only)	2E-04	3.6E-09	1.6E-07	9.6E-08	9.2E-08
Pu-239 (winkle only)	2E-04	3.8E-09	1.7E-07	1.1E-07	1.0E-07
Pu-240 (winkle only)	2E-04	3.8E-09	1.7E-07	1.1E-07	1.0E-07
Pu-241 (winkle only)	2E-04	4.4E-11	2.3E-09	2.0E-09	1.9E-09
Am-241 (winkle only)	2E-04	1.1E-09	1.5E-07	8.8E-08	8.0E-08

a The gastro-intestinal absorption factor does not apply to neonates or infants aged below about one year.

Table 50. Committed effective doses per unit intake for inhalation

Radionuclide	Lung absorption type	f_1[a]	Dose per unit intake (Sv Bq^{-1})				Basis for choice of lung absorption type
			Foetus	1 year old	10 year old	Adult	
H-3 organic	V	1E+00	6.3E-11	1.1E-10	5.5E-11	4.1E-11	Organically bound
C-14	M	1E-01	6.6E-11	6.6E-09	2.8E-09	2.0E-09	ICRP default
Co-60	M	1E-01	1.2E-09	3.4E-08	1.5E-08	1.0E-08	ICRP default
Sr-90	M	1E-01	1.0E-08	1.2E-07	5.4E-08	3.8E-08	ICRP default
Zr-95	M	2E-03	4.6E-10	2.1E-08	9.0E-09	6.3E-09	ICRP default
Nb-95	M	1E-02	1.6E-10	5.2E-09	2.2E-09	1.5E-09	ICRP default
Tc-99	M	1E-01	8.3E-11	1.3E-08	5.7E-09	4.0E-09	ICRP default
Ru-106	M	5E-02	4.1E-10	1.1E-07	4.1E-08	2.8E-08	ICRP default
Ag-110m	M	5E-02	1.5E-09	2.8E-08	1.2E-08	7.6E-09	ICRP default
Sb-125	M	1E-02	2.6E-10	1.6E-08	6.8E-09	4.8E-09	ICRP default
I-129	F	1E+00	1.5E-08	8.6E-08	6.7E-08	3.6E-08	ICRP default
I-131	F	1E+00	8.1E-09	7.2E-08	1.9E-08	7.4E-09	ICRP default
Cs-134	F	1E+00	3.0E-09	7.3E-09	5.3E-09	6.6E-09	ICRP default
Cs-137	F	1E+00	2.0E-09	5.4E-09	3.7E-09	4.6E-09	ICRP default
U-234	M	2E-02	4.9E-08	1.1E-05	4.8E-06	3.5E-06	ICRP default
U-235	M	2E-02	4.5E-08	1.0E-05	4.3E-06	3.1E-06	ICRP default
U-238	M	2E-02	4.4E-08	9.4E-06	4.0E-06	2.9E-06	ICRP default
Pu-238	M	5E-04	1.1E-06	7.4E-05	4.4E-05	4.6E-05	ICRP default
Pu-239	M	5E-04	1.2E-06	7.7E-05	4.8E-05	5.0E-05	ICRP default
Pu-240	M	5E-04	1.2E-06	7.7E-05	4.8E-05	5.0E-05	ICRP default
Pu-241	M	5E-04	1.4E-08	9.7E-07	8.3E-07	9.0E-07	ICRP default
Am-241	M	5E-04	3.2E-07	6.9E-05	4.0E-05	4.2E-05	ICRP default
Cm-242	M	5E-04	5.1E-08	1.8E-05	7.3E-06	5.2E-06	ICRP default
Cm-243	M	5E-04	3.1E-05	6.1E-05	3.1E-05	3.1E-05	ICRP default
Cm-244	M	5E-04	2.6E-07	5.7E-05	2.7E-05	2.7E-05	ICRP default

a The gastro-intestinal absorption factor does not apply to neonates or infants aged below about one year.

b No default inhalation class recommended – most restrictive value cited by ICRP used.

Table 51. Collective dose commitment (man Sv per Bq discharged, integrated to 500 years): atmospheric discharges

Radionuclide	UK	EU	World
H-3	6.7E-16	1.2E-15	1.5E-15
C-14	2.0E-13	1.0E-12	1.3E-11
Kr-85	4.3E-18	1.5E-17	2.6E-16
Sr-90	1.9E-12	8.8E-12	8.8E-12
Ru-106	3.1E-13	4.2E-13	4.2E-13
Sb-125	1.2E-13	1.7E-13	1.7E-13
I-129	4.5E-11	2.1E-10	2.9E-10
I-131	7.8E-13	4.8E-13	4.8E-13
Cs-137	1.8E-12	6.1E-12	6.1E-12
Pu-239 & Pu-240	1.7E-10	2.4E-10	2.4E-10
Pu-241	3.0E-12	4.4E-12	4.4E-12
Am-241	1.4E-10	2.0E-10	2.0E-10

EU is defined as the population of the EU12 member states, 360 million

Table 52. Collective dose commitment (man Sv per Bq discharged, integrated to 500 years): liquid discharges

Radionuclide	**UK**	**EU**	**World**
H-3	4.6E-19	1.9E-18	3.5E-17
C-14	2.0E-13	6.6E-13	6.8E-12
Co-60	6.7E-14	1.9E-13	2.4E-13
Sr-90	7.0E-16	1.8E-15	3.0E-15
Zr-95	7.3E-17	1.5E-16	1.6E-16
Nb-95	1.7E-17	3.5E-17	3.8E-17
Tc-99	2.5E-15	7.6E-15	9.5E-15
Ru-106	1.9E-14	5.1E-14	5.6E-14
I-129	1.9E-14	5.7E-14	2.2E-13
Cs-134	1.3E-14	3.0E-14	4.6E-14
Cs-137	1.6E-14	4.1E-14	7.1E-14
Ce-144	6.9E-17	1.8E-16	2.0E-16
Pu-239 & Pu-240	3.0E-13	8.4E-13	9.8E-13
Pu-241	2.5E-14	7.1E-14	7.9E-14
Am-241	1.3E-12	3.6E-12	3.9E-12
Cm-242	2.3E-15	6.1E-15	6.8E-15
Cm-243 & Cm-244	4.3E-14	1.1E-13	1.2E-13

The collective dose factors include the contribution from the first decay product where appropriate.
EU is defined as the population of the EU12 member states, 360 million