Report by the Scottish Environment Protection Agency for the Chapelcross Site Stakeholder Group on tritium levels in the local Chapelcross environment.

Executive Summary

Following a public enquiry to SEPA over the level of tritium in groundwater, SEPA carried out sampling of surface waters around the Chapelcross site. Separately SEPA had already entered discussions relating to tritium in surface and groundwater at the Chapelcross site with Magnox North Limited.

Disposals of tritium to air from the tritium processing plant, has resulted in tritium being ubiquitous in and around the Chapelcross site. A distinctive footprint of these disposals can be observed. The effects can still be seen in and around the site extending to the Winterhope reservoir some 20 Km north west of the site. The tritium processing plant was operated between 1980 and 2005. Its decommissioning has passed to the Nuclear Decommissioning Authority and the plant is currently undergoing Post Operational Clean Out (POCO) by Magnox North.

Rainwater samples have been collected weekly and analysed for tritium by the site operator and spikes in tritium concentrations have occurred with a peak recorded value in October 2005 of 24,000 Becquerels per litre (Bq l^{-1}) of tritium. Current concentrations in rainwater are of the order of 20 Bq l^{-1}. Tritium is also detectable[1] in Gullielands Burn, in aggregated quarterly milk samples and other foods collected from around the Chapelcross site.

An independent environmental monitoring programme, RIFE, is carried out on behalf of SEPA to assess the impact of authorised discharges. As part of the reporting in RIFE an assessment of the annual radiation dose to the representative person is carried out based upon the results of the monitoring programme. The latest published results are for 2008. The annual dose from terrestrial food consumption and non-food pathways (the terrestrial representative person) was assessed as 0.023 mSv. The presence of tritium accounted for about 0.01 percent of the dose. The total dose is about 2 percent of the dose limit for members of the public of 1 milliSievert.

Magnox North has identified the benefit of reducing aerial discharges during the decommissioning of the processing plant. SEPA has asked Magnox North to formulate an action plan that would accommodate the local environment to return to typical UK surface water tritium levels. It is acknowledged that by radioactive decay alone this would take around 80 years if no more tritium was deposited in the local environment. A regulatory view on the management of contaminated groundwater on the nuclear site is given. Further actions and considerations are identified.

Background

A facility for the processing of tritium was built for the Ministry of Defence on the Chapelcross site. It was operated by BNFL between 1980 and March 2005. Since that time it has been undergoing Post Operational Clean Out (POCO). Currently, this is carried out by Magnox North. The extant Authorisation was issued to BNFL under The Radioactive Substances Act 1960 in March 1986. It was transferred to Magnox North in

[1] Radioactivity in Food and the Environment Series. SEPA.

2006. The Authorisation permits the gaseous disposal of 1000 petabecquerels per year of elemental tritium and 5 petabecquerels per year of tritium in non elemental form, subject to Best Practical Means to minimise the discharge. Atmospheric releases of tritium have resulted in elevated[2] tritium concentrations in surface and groundwater on and in the locality of the site. Following the release of a report[3] that in part explored management options for tritiated groundwater on the Chapelcross site, the site operator was approached by a third party for information on the actual tritium levels on and around Chapelcross. Magnox North supplied information regarding the site itself but referred the inquirer to SEPA for details regarding the wider environment. Whilst measurements had been made by SEPA in the past they had been targeted to assess doses to the representative person (formally known as the critical group) and thus, did not give a complete picture. Sampling of surface water was therefore undertaken by SEPA in May 2009. This report summarises the position to date with regard to tritium on and around the Chapelcross site.

Surface water sampling by SEPA

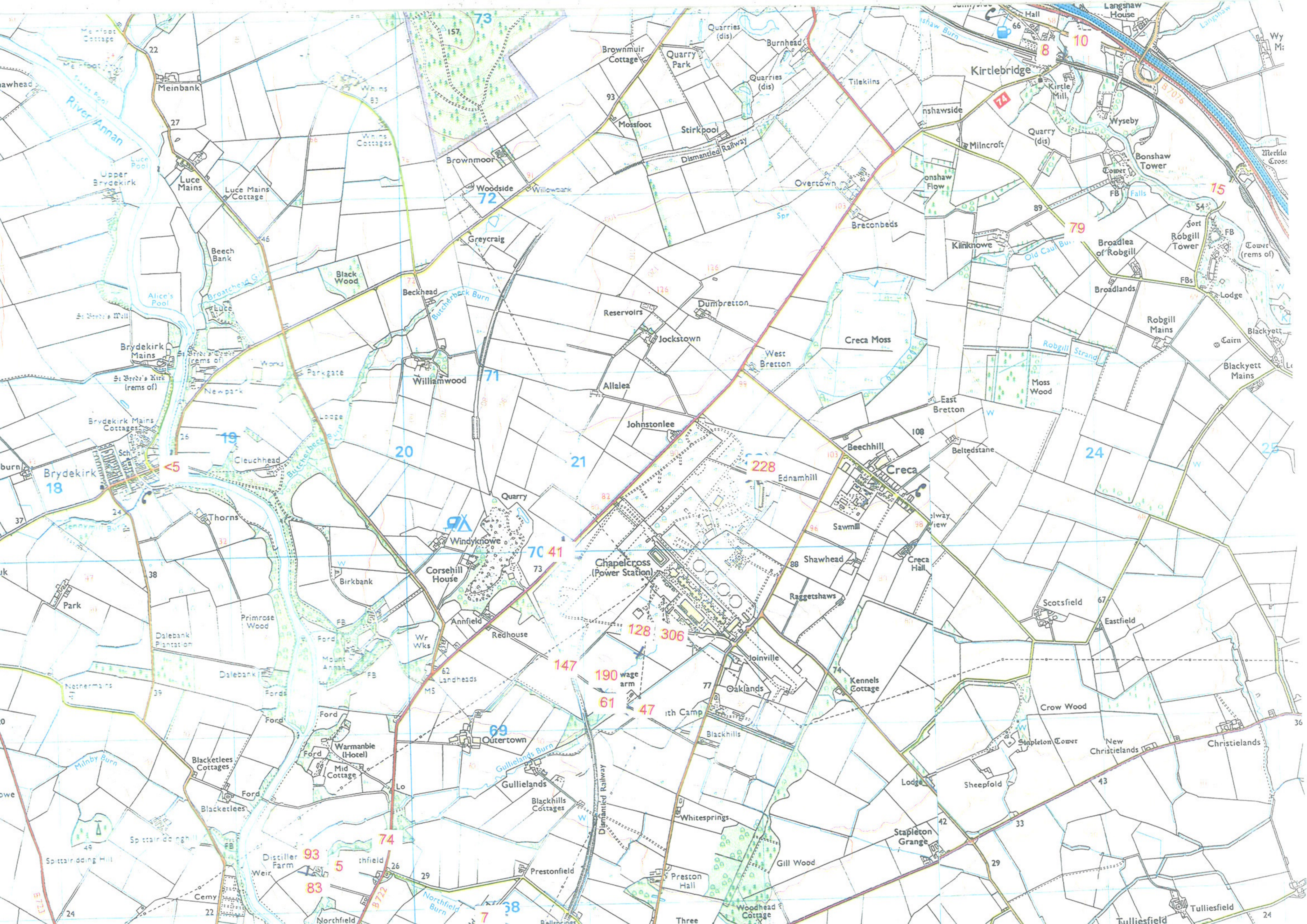
The results of SEPA's sampling undertaken on 28th May or 4th April are given in Table 1 below and illustrated in Figures 1 and 2. Samples were analysed for tritium and Caesium-137 by the Health Protection Agency at their laboratory. All samples contained less than 0.1 Bq l^{-1} of Caesium-137.

Location	Tritium Bq l^{-1}	Location	Tritium Bq l^{-1}
Kirtlewater at NY23927271	7.5 ± 2.9	Merkland Burn at NY24797196	15.2 ± 3.3
Longshore Burn at NY23937275	10.3 ± 3.1	Dornock Burn at NY23646758	9.9 ± 3.1
Old Caul Burn at NY23917175	78.7 ± 7.2	Gullielands Burn at NY19886839	74.3 ± 6.9
Annan Distillery race at NY19486824	82.6 ± 7.4	Gullielands Burn, Annan Distillery at NY19496828	92.8 ± 8.1
Northfield Burn, Annan Distillery at NY19496826	5.1 ± 2.8	Upper Northfield Burn at NY20526804	7.4 ± 2.9
Kelhead at NY14656912	<5	River Annan, Hoddom Bridge at NY16397270	<5
River Annan, Brydekirk at NY18717044	<5	Gullielands Burn, entry to Chapelcross at NY22007040	228 ± 18
Burn west entry to Chapelcross at NY20956999	41.1 ± 4.8	Exit culvert west chamber at NY21476952	128 ± 11
Exit culvert east chamber at NY21476952	306 ± 23	Burn, railway bridge at NY20926931	147 ± 12
Outlet sewage works at NY21226916	61.1 ± 6.0	Run off from car park at NY21236914	47.4 ± 5.2
Gullielands Burn at NY21136920	190 ± 15	River Annan, Annan at NY19056656	<5
Kirtlewater, Rigg at NY29396704	7.8 ± 2.5	River Sark, Gretna at NY32796701	<5
River Annan, Annan at NY18946699	<5		

[2] General levels of tritium in surface and drinking water in the UK are recorded in RIFE at below 4 Bq l^{-1} and for Scotland below 1 Bq l^{-1} reflecting the result of different limits of detection achieved for the methods used.

[3] Chapelcross BPEO review workshop. Summary Report. ENTEC. March 2009.

Two surface water flows enter the Chapelcross site namely Gullielands Burn to the north of the site and an unnamed burn to the west of the site. Gullielands Burn is culverted from its entry to the site (in the north) to its exit in the south. At its exit from the site the culvert is split vertically in two with separate streams of water emerging and mixing together on a concrete apron. This is then diverted through an oil interceptor and back to the burn. The detailed construction of the culvert is not known. It is probable that one side of the culvert channels water from Gullielands Burn and the other side channels the burn that enters from the west side of the site. A Chapelcross site drainage plan shows the connections of on site surface water drains to the culvert. Visual observation of the burn flow rates at the time of sampling would support this assumption. Although the site has recently begun measuring the flow of Gullielands Burn on exit from the site it is not measured on entry. On entry to the site the burn was observed as a very low flow (a mere trickle) and had a tritium result of 228 Bq l^{-1}, on exit from the east side of the culvert the flow was observed as substantial and gave a tritium result of 306 Bq l^{-1}. The visually observed flow of the west burn on entry to the site (tritium level 41 Bq l^{-1}) was less than on exit (tritium level 128 Bq l^{-1}).



Kirtlebridge
Langshaw House
Hall
Kirtle Mill
Wyseby
Bonshaw Tower
Milncroft
Quarry (dis)
Kilnknowe
Broadlea of Robgill
Robgill Tower
Broadlands
Robgill Mains
Lodge
Cairn
Blackyett Mains
Moss Wood
Robgill Strand
Old Caul Burn
East Bretton
Beltedstane
Beechhill
Creca
Creca Moss
Creca Hall
Sawmill
Shawhead
Raggetshaws
Ednamhill
West Bretton
Dumbretton
Jockstown
Reservoirs
Allalea
Johnstonlee
Chapelcross (Power Station)
Joinville
Oaklands
Blackhills
Kennels Cottage
Scotsfield
Eastfield
Crow Wood
Stapleton Tower
New Christielands
Christielands
Sheepfold
Stapleton Grange
Gill Wood
Whitesprings
Preston Hall
Woodhead Cottage
Tulliesfield
Prestonfield
Gullielands
Gullielands Burn
Blackhills Cottages
Dismantled Railway
Outertown
Landheads
Redhouse
Annfield
Corsehill House
Windyknowe
Quarry
Birkbank
Williamwood
Beckhead
Butcherbeck Burn
Greycraig
Woodside
Brownmoor
Brownmuir Cottage
Quarry Park
Mossfoot
Stirkpool
Quarries (dis)
Burnhead
Tilekilns
Overtown
Breconbeds
Black Wood
Parkgate
Newpark
Cleuchhead
Thorns
Brydekirk
Brydekirk Mains
Brydekirk Mains Cottages
Upper Brydekirk
Alice's Pool
River Annan
Luce Mains
Luce Mains Cottage
Beech Bank
Meinbank
Park
Primrose Wood
Dalebank Plantation
Dalebank
Warmanbie (Hotel)
Mid Cottage
Blacketlees Cottages
Blacketlees
Distiller Farm
Weir
Milnby Burn
Spittalridding Hill
Northfield
Northfield Burn
B722
B723
B7076


A74(M)
A701
A708
A75
A7
A74
DUMFRIES
LOCKERBIE
MOFFAT
ANNAN
LANGHOLM
Lochmaben
Beattock
Gretna
Longtown
Gretna Green
Eskdalemuir
Castle O'er
Kirkpatrick-Fleming
Lochar Moss
Blackshaw Bank
Solway Moss
Hart Fell
Grey Mare's Tail (Waterfall)
Robert Burns Centre and Burns Mausoleum
Sweetheart Abbey
Caerlaverock Castle
ROMAN FORT
ROMAN CAMP
ROMAN FORTLET
Southern Upland Way
LOWTHER HILLS
ESKDALEMUIR FOREST
CRAIK FOREST
ETTRICK FOREST
FOREST OF AE

Tritium discharges to Atmosphere

Modelling work carried out by the National Radiological Protection Board, NRPB, (now the Health Protection Agency) in the late 1970's to investigate dispersion from gaseous discharges from the tritium plant predicted that the main deposition of tritium would be towards the northern boundary of the site and towards the settlement of Creca. To the north of the site Creca Moss drains south via Gullielands Burn and north via the Old Caul Burn. The measured tritium concentration in the Old Caul Burn (79 Bq l^{-1}) and Gullielands Burn (228 Bq l^{-1}) would tend to support the NRPB modelling work of deposition nearer to the northern boundary of the site. It should be noted that on the southern edge of Creca Moss, peat extraction is taking place and it is possible that this is having an effect on Gullielands Burn. To the North of Creca Moss streams drain to Kirtlewater and decreasing concentrations of tritium are seen in burns draining from the north side of the Kirtlewater valley, namely Merkland (15 Bq l^{-1}l) and Longshore Burn (10 Bq l^{-1}). Further away slightly elevated concentrations of tritium are observed[4] in Black Esk, Purdomstone and Winterhope Reservoir as indicated in Table 2 below. Concentrations of tritium in Gullielands Burn decrease with distance from the site by dilution as less tritiated water enters the burn from various tributaries.

Year	Black Esk	Purdomstone	Winterhope
2008	<1.1	2.5	<4.0
2007	1.4	2.7	5.3
2006	<1.3	2.3	1.5
2005	3.0	5.2	10
2004	2.4	-	23
2003	3.4	-	6.7
2002	Not sampled	-	Not sampled
2001	3.0	-	21
2000	4.2	-	19
1999	<1.0	-	<1.0
1998	<1.0	-	<1.0
1997	1.9	-	18
1996	<1.3	-	<1.1

Table 2. Tritium activity in water samples. Becquerels per litre.

The annual disposal of tritium to atmosphere is given[5] in Table 3. The results have been normalised (by radioactive decay) to give an indication of the past disposals contribution to today's burden. For example, of the 1,500 TBq of tritium released and deposited in the environment in 1980, by radioactive decay (half life 12.26 years) alone only 297 TBq would remain in the environment. This value will have been further reduced from the local environment due to mobilisation and migration in surface water away from the local environment.

[4] RIFE 14. Radioactivity in Food and the Environment. 2008. SEPA 2009.
[5] Data provided by Magnox North

Year	Tritium Discharged (TBq)	
	Actual discharge	Normalised to 1 January 2010[6]
1980	1500	284
1981	2100	420
1982	1700	360
1983	2300	515
1984	1400	332
1985	2200	552
1986	1600	425
1987	1550	435
1988	1850	550
1989	1440	453
1990	1930	642
1991	1370	482
1992	1470	547
1993	1510	595
1994	1622	676
1995	1587	700
1996	1124	525
1997	1031	509
1998	1272	665
1999	1424	787
2000	1498	876
2001	844	522
2002	760	498
2003	410	284
2004	594	435
2005	300	232
2006	121	99
2007	85	74
2008	68	62

Table 3. Annual disposal of tritium to atmosphere. Tera Becquerels.

Records retained by the site operator show that when the plant was operational the daily activity of tritium disposed to air varied by around an order of magnitude within any single month. Since closure of the plant the activity of tritium disposed to air has been reasonably constant with the exception of March 2009 when a process cell was being vented.

Tritium in rainwater

Tritium is a highly mobile radionuclide and readily exchanges with water in the environment. Deposition depends upon a number of factors but particularly is affected by the prevailing atmospheric conditions at the time of its disposal. If deposition occurs the resultant activity deposited is clearly related to the activity disposed. As already noted

[6] Half life of 12.28y assumed and 1 June of each year used for the annual disposal. Normalised figures have been rounded up.

modelling work carried out by the National Radiological Protection Board, NRPB predicted that the main deposition of tritium would be towards the northern boundary of the site and towards the settlement of Creca. Rainwater that is collected, sampled and analysed on a weekly basis by the site operator at 5 locations around the site would tend to support this modelling work. Figure 3[7] covering the period 2001 - 2009 shows measured tritium levels in the collected rainwater. Currently, the measured concentration of tritium in rainwater is of the order of 20 Bq l^{-1}, which was not the case whilst the tritium plant was operational, nor shortly after closure as can be seen in Figure 3.

Tritium in burn water entering and leaving the site.

The site operator samples and analyses Gullielands Burn as it enters the site and exits the site, and close to the sewage farm. The results[8] are shown in Figure 4. A correlation to the levels of tritium being deposited, as measured in rainfall, can be observed.

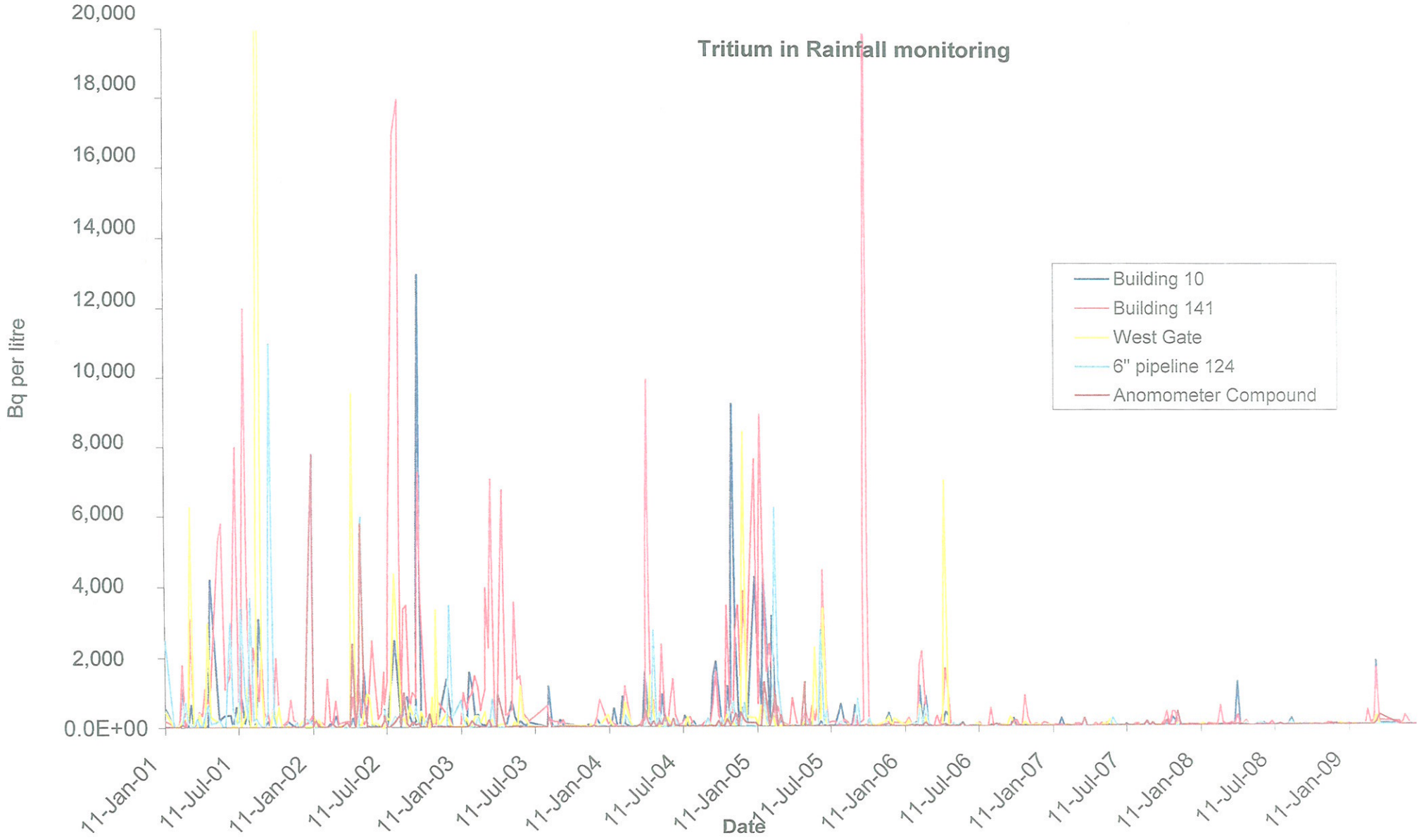
On site tritium monitoring.

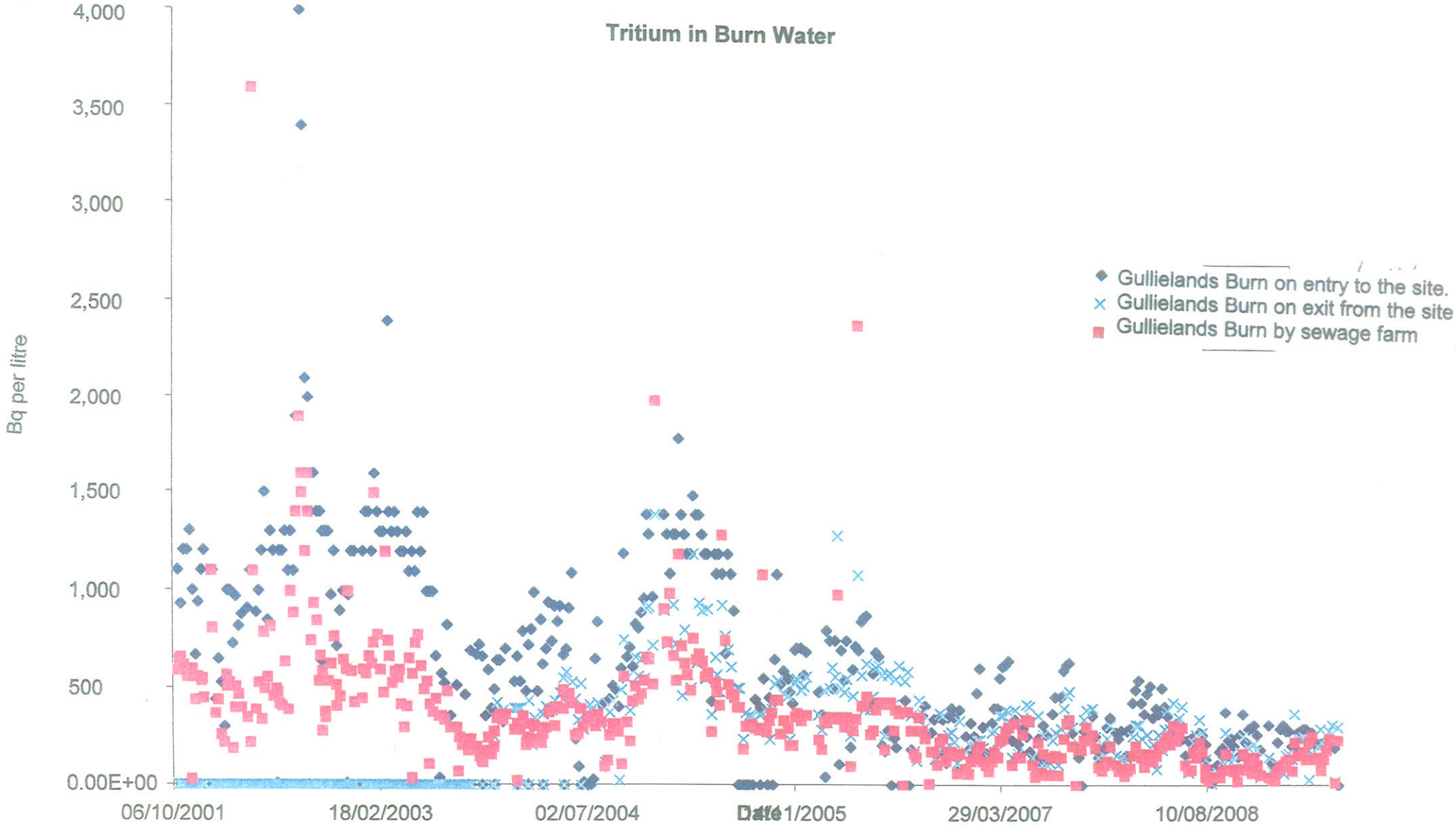
The site operator has since 2005 analysed a number of water samples obtained from boreholes of varying depth across the site. They show tritium concentrations in the range 10 – 2000 Bq l^{-1}. Inspection by SEPA and discussion with the site operator has confirmed that localised water movement on the site is not fully understood, however the Site operator believe that they have a good knowledge of mass groundwater movement across the site. SEPA has requested copies of a range of information and data held by the site operator. SEPA intends to use the information to carry out a detailed assessment of the groundwater movement on the site and identify any relevant information gaps that exist. Data and information that has been requested include: the logs from borehole drilling; the measurement of groundwater levels in the boreholes with time; and, details of the site drainage infrastructure.

In 2007, the cooling tower sub basement drainage system was blocked with a proprietary drain seal when crushed concrete infill was used for restoration. Subsequently, groundwater has built up in the sub basements and due to the presence of the crushed concrete has a high pH. Attempts to drain the sub basements via the effluent pipeline have been made and disposals made between June 2009 and September 2009 had tritium concentrations in the range 84 to 390 Bq l^{-1}.

The blower pits, motor generator pits and cable basements of the reactors are currently prone to groundwater ingress which has recently been disposed via the effluent line. Tritium concentrations were in the range <10 – 7,560 Bq l^{-1} as recorded in the Chapelcross disposal record. Disposal batches have been of the order of 45 m^3.

[7] Supplied by Magnox North
[8] Supplied by Magnox North


Tritium in Rainfall monitoring
Bq per litre
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0.0E+00
11-Jan-01
11-Jul-01
11-Jan-02
11-Jul-02
11-Jan-03
11-Jul-03
11-Jan-04
11-Jul-04
11-Jan-05
11-Jul-05
11-Jan-06
11-Jul-06
11-Jan-07
11-Jul-07
11-Jan-08
11-Jul-08
11-Jan-09
Date
Building 10
Building 141
West Gate
6" pipeline 124
Anomometer Compound


Tritium in Burn Water
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0.00E+00
Bq per litre
06/10/2001
18/02/2003
02/07/2004
29/03/2007
10/08/2008
Gullielands Burn on entry to the site.
Gullielands Burn on exit from the site
Gullielands Burn by sewage farm

Radioactivity in food and the environment

An independent environmental monitoring programme is carried out on behalf of SEPA to assess the impact of authorised discharges. Within this programme, a variety of food sources close to the site are collected and analysed for radioactivity.

One food which is measured is milk, which is sampled at a number of farms close to and surrounding the site. This is bulked and analysed for tritium on a quarterly basis. The results for the period 1996 to 2008 are given in the table 4 below.

Year	Mean Bq l^{-1}	Maximum Bq l^{-1}
1996	94	180
1997	91	170
1998	120	180
1999	44	57
2000	<62	160
2001	72	140
2002	<67	140
2003	<26	<56
2004	<18	54
2005	<27	160
2006	<13	38
2007	<8	20
2008	<6.3	<12

Table 4. Tritium levels in milk. Becquerels per litre. Data Source: RIFE-14.

Comparison of this data to the measurement of tritium in rainwater in figure 2 shows an apparent positive relationship between the peak measurements in milk. It is noted that as the sample is a spatial and temporal bulk, this data would not lend itself to detect any short term increased release of tritium. However, examination of table 5 below indicates a generally reducing concentration of tritium in foodstuffs which is most likely a reflection of reduced atmospheric disposals of tritium.

Material	Mean radioactivity concentrations (fresh) Bq kg^{-1} or Bq l^{-1} of Tritium												
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Milk	88	68	84	51	<62	72	<67	<26	<18	<27	<13	<8.2	<6.3
Milk max	180	170	180	90	160	140	140	<56	54	160	38	20	<12
Apples					190	100	73	22	<32	23	<7.2	14	<5
Apples max					340	150	86	35	120	23	9.3	14	
Barley					550	150	140	99	<7.8	7.5		<5	<5
Barley max					570	250	260	100	11	7.5			
Beetroot					28								
Blackberries					2200					5.9		20	<5
Cabbage					70	110	37	<10	8.8	52	6	26	<5
Cabbage max					110	110	61	21	9.6	52		26	
Carrots					<56	<54			<5	51		47	
Carrots max					100	100				51		47	
Cauliflower							18	5.2					
Comfrey						30		10	9.2				

Material	Mean radioactivity concentrations (fresh) Bq kg^{-1} or Bq l^{-1} of Tritium												
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Crab apples										9.7	5	<5	<5
Damsons					290	20		13	<5				
Elderberries						150			<5		5.7		
Goose							5.1		<5				
Ground Elder					500		<5						
Hawthorn berries						100						<5	
Honey										110	100	46	6.9
Maize					58	50		69	<5				<5
Mallard					<5	45	9.2	<5.6	<5		<5	<5	<5
Nettles					420		5.5	24					
Onion					64	<5							
Onion max					89	<5							
Partridge									<5		<5		
Peas									<5				
Pheasants					<5	21	15	<9.1	<5		<5	<5	
Plums					280								
Potatoes					65	<24	38	<11	<7.8	56	<5	<5	
Potatoes max					85	<24	130	31	14	56	<5	<5	
Rabbit													<5
Rhubarb					37		49	110	30				
Rosebay willow herb							6		5.2				
Rosehips					180		79	6.8		<5	19	44	<5
Rowan berries											22		13
Teal												<5	<5
Tomatoes								5.2					
Turnips					74	120	35	27	<22	52	<5	120	<5
Turnips max					110	120	43	46	50	52	<5		
Venison												<5	
Wheat							<5	9.9			<5		<5
Widgeon					<5	32	6.5				<5	<5	<5
Wood pigeon					8			<5.4					
Wild Greens						<5							
Grass	<520	<160	n/a	<82	100	<120	<24	26	<13	<92	<9.4	<530	<6.7
Grass max	1900	510	n/a	160	480	350	46	90	41	280	22	1200	12
Soil					36	<23	<57	<9.5	<15	<27	<12	<8.7	<7.6
Soil max					130	47	260	23	49	83	26	17	12

Table 5. Tritium levels in environmental samples. Becquerels per kilogramme (litre). Data Source: RIFE-14.

Some members of the public close to nuclear installations can receive higher doses than other members of the population. This can be due to their higher than average consumption of certain foodstuffs (as established by habit surveys), frequenting certain areas or living in close proximity to the site. In predicting radiological impacts to man, the representative person (formally the critical group) is used. For a given source of

radioactive discharges, this is the small number of members of the public who are likely to receive the highest radiation dose as a result of that source. As part of the reporting in RIFE an assessment of the annual radiation dose to the representative person is carried out based upon the results of the monitoring programme. For the 2008 results the annual dose from terrestrial food consumption and non-food pathways (the terrestrial representative person) was assessed as 0.023 mSv. The presence of tritium accounted for about 0.01 percent of the dose. For fishermen, the dose to the representative person was assessed as 0.022 mSv and dominated by external irradiation whilst occupying intertidal areas. The presence of tritium accounted for about 0.003 percent of the dose. These doses are well below the annual dose limit of 1 mSv. The small contribution to the total dose by tritium is a reflection of it relatively low toxicity to man[9]

In measuring the level of tritium in environmental samples, the form of the tritium is not generally determined. On release from the CXPP the tritium is believed to be either in elemental form or as tritiated water. On deposition/exchange in the environment the tritium may become organically bound, and this form of tritium is known as OBT (organically bound tritium). OBT may be more persistent in the environment. Its dose per unit intake[10] is likely to be higher than that for tritiated water by a factor of 3 or so. In 1999 some measurements of OBT levels in environmental samples were made and are given in Table 6 below.

Location	Sample type	Tritium Bq l^{-1}	OBT Bq l^{-1}
Annan above tidal weir	Water	8.1	3.3
	Sediment	3.8	0.4
	Grass	21	4.4
Gullielands Burn, 500m below station	Water	430	Not detected
	Sediment	94	0.8
	Grass	81	29
Purdomstone Reservoir	Water	12	Not detected
	Sediment	4.4	1.1
	Grass	19	7.0

Table 6. Tritium and OBT levels in certain environmental samples. Becquerels per litre. Data Source: RIFE-14.

For illustrative purposes using the level of tritium measured in rainwater and assuming that it is all OBT if an adult residing close to the site boundary was to obtain all of their drinking water from collected rainwater, then their annual dose (assuming a dose per unit intake for OBT of 6.0 10^{-11} Sv Bq^{-1} [11]) in 2005 from OBT would be of the order of 0.056 mSv and in 2008 0.002 mSv. The doses would be well below the annual dose limit of 1 mSv.

By considering the total number of people exposed to discharges from a site and the radiation dose they receive as a consequence (known as the collective dose), the optimisation of the discharge can be examined. The principle of optimisation of dose or

[9] SEPA acknowledge that the HPA Advisory Group on Ionising Radiation (AGIR) has recommended that the RBE rounded value of two is used for retrospective assessments rather than the current RBE of one.
[10] J Harrison. 2009. Doses and risks from tritiated water and environmentally organically bound tritium. Journal of Radiological Protection. V29, No.3.
[11] RIFE-11

risk is derived in Council Directive 96/29/EURATOM from the recommendations of the ICRP and has been enshrined in European Directives, (EC Directive 80/836, 84/467 and 96/29/Euratom). ICRP 60 states the principle as:

> *"In relation to any particular source within a practice, the magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposures where these are not certain to be received should be kept as low as reasonably achievable, economic and social factors being taken into account."*

The requirement to keep all exposure to radiation as low as reasonably achievable, taking into account economic and social factors, the ALARA requirement, as part of the optimisation principle, is given effect within authorisations issued by SEPA by the inclusion of conditions requiring the Authorisation Holder to use the best practicable means (BPM) to minimise the activity in all the waste discharged. It also requires BPM to dispose of radioactive waste at times, in a form and in a manner so as to minimise the radiological effects on the environment and members of the public.

As can be seen in figures 1 and 2 past disposals of tritium have left a distinctive footprint in an around the Chapelcross site. The "collective dose" from exposure to this footprint is not considered in RIFE. SEPA is commissioning a study to examine and estimate "collective dose" based upon the results of environmental monitoring and habit survey data relevant to considering discharges from Chapelcross.

Regulation

Policy

Groundwater in and around the Chapelcross site has become contaminated predominantly with tritium following the authorised disposal of radioactive waste from the site.

SEPA's policy advisory note[12] is pertinent to this contamination. The note records that:

"Articles and substances that have been contaminated as a result of the disposal of radioactive waste [whether authorised or not] should not be regarded as radioactive material but may be regarded as radioactive waste providing that they first meet the definition of waste given in the Act". It further notes that:

"It is likely that areas surrounding nuclear sites (land, buildings, crops etc.) will be contaminated as a result of authorised discharges of radioactive waste. Only if such contaminated material falls within the definition of waste would it be possible for it to be considered radioactive waste as described above. If accumulation or disposal of such material is occurring in conjunction with an undertaking and no exemption order is applicable, such radioactive waste should be regulated in accordance with the requirements of the Act.", and

"*It is undesirable that authorised disposals of radioactive waste by dilution or dispersal into the environment create a situation that requires further authorisation. Therefore it is SEPA Policy that such authorisations should not be granted.*"

[12] RASPAN 2007-01 dated 29 August 2007.

Past SEPA Decisions

SEPA's Environmental Protection and Improvement Management Team (EPIMT) considered the requirement for an authorisation to dispose of tritiated groundwater from a trial remediation of solvent contaminated ground at Chapelcross. Levels of tritium in the groundwater were measured by SEPA at 150 Bq l^{-1}. EPIMT required any waste to be disposed to be made in accordance with the sites authorisation. The authorised route is to the Solway Firth via the effluent pipeline.

A request to SEPA's Regulatory Review Team concerned the disposal of groundwater that had accumulated in the cooling tower sub basement recommending its disposal via the pipeline to the Solway (the authorised disposal route for radioactive waste) but proposing that the requirements to dispose around the high tide should be set aside in this case. Levels of tritium in the cooling tower sub basement water were measured by SEPA at 225 Bq l^{-1}. The proposal was endorsed by the Regulatory Review Team.

In June 2008 SEPA agreed[13] that reactor cable basement water (tritium levels between 90 and 5000 Bq l^{-1}) could be disposed via the authorised route out with the tidal window set in the authorisation.

Regulatory Position

Solid radioactive waste contaminated with low levels of radioactivity (0.4 Bq g^{-1}) is exempt[14] from the requirements of the Radioactive Substances Act. There is no equivalent exemption order for liquids.

The site surface water drainage system and the local burns, particularly Gullielands Burn are contaminated with tritium. This tritium has been disposed to the environment via the discharge stack. Once released from the plant to the stack it has passed the last point of control and it then entered the environment. However, in some instances on the nuclear licensed site tritium contaminated water has accumulated and there is a need for it to be discarded by the site operator. In these cases the discharged radioactive waste that was thought to be beyond the last point of control has once again become under the control of the site operator. An example of this is the tritiated water accumulating in various reactor basements, currently being actively managed by the site operator and periodically pumped to and disposed via the effluent pipeline.

On the nuclear licensed site, where contaminated water is not being treated or actively or passively accumulated and then discarded by the site operator (such as in the rainwater drainage system) it is viewed to be beyond the last point of control. Consequently it is not considered by SEPA to be radioactive waste arising from a practice being carried out on the site. It is recognised that the site operator could if justified carry out an intervention and undertake active management of some or all of the surface and groundwater on the site. However it is important that in cases where an intervention takes place the benefits of carrying out any intervention should out way the detriments from carrying it out.

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[13] As a 1 off to drain the reactor basements for safety reasons.

[14] S.I. 1986/1002. The Radioactive Substances (Substances of Low Activity) Exemption Order 1986.

On the nuclear site and where contaminated groundwater is being actively managed and there is a need for it to be discarded it would be consistent with the description of radioactive waste. In these cases the waste should be disposed in accordance with the site radioactive waste authorisation.

Currently the disposal to air of tritium results in rainwater being contaminated to a level of around 20 Bq l^{-1}. Whilst SEPA will look to the site operator to reduce this under their decommissioning plans for the tritium plant there is no proposal to take regulatory action at this juncture.

Changes to the Radioactive Substances Act 1993 and new Exemption Orders are planned and were recently subject to public consultation. The proposal consulted upon was, amongst other things, to exempt from regulation tritium in liquids at a level below 100 Bq l^{-1}.

Taking all this in to consideration it is SEPA's current position that tritium in water at Chapelcross at levels above 100 Bq l^{-1}, if actively managed must be disposed in accordance with the requirements of the Authorisation issued under the Radioactive Substances Act.

Further Considerations and Actions

- SEPA has asked the site operator to formulate an action plan that would accommodate the local environment to return to normal UK surface water tritium levels. At the very least this should be by natural attenuation (sometime referred to as "the field half life") and by radioactive decay. In formulating the action plan the site operator will need to give due consideration to the practicalities and benefits and detriments of any actions that can be taken to manage tritiated water that resides on the site, including mitigating its migration into Gullielands Burn.

- In respect of BPM Magnox North have already identified in their 2007 application for a decommissioning authorisation that;

  "With the exception of tritium discharges arising from decommissioning the CXPP, it has been argued that current measures will continue to represent BPM for limiting aerial discharges from the site. Detailed plans for decommissioning the CXPP are currently being developed. Appropriate means of limiting tritium discharges will be incorporated into those plans. Nevertheless, even using BPM, there will be some aerial discharge. Per unit discharge, the dose resulting from aerial emissions of tritium from Chapelcross is greater than that from discharges to the marine environment. Consequently, during CXPP decommissioning activities, measures to reduce aerial discharges of tritium at the expense of increased aquatic discharges would be beneficial in reducing the doses to individuals exposed to these discharges".

  SEPA will ensure that BPM is utilised during the decommissioning of Chapelcross and this will be addressed during the determination of the application.

- SEPA has requested copies of a range of information and data held by the site operator. SEPA intends to use the information to carry out a detailed assessment of the groundwater movement on the site and identify any gaps in knowledge that exist. The output of this work should be valuable to the site operator in formulating their "tritium" action plan.

- Current and past disposals of tritium have left a distinctive footprint in an around the Chapelcross site. SEPA will undertake a small study to examine and estimate "collective dose" based upon the results of environmental monitoring and habit survey data relevant to considering discharges from Chapelcross. Once completed the results will be used to consider if and how disposals from the CXPP are and should be optimised as given effect within authorisations by the inclusion of BPM conditions. This has already been identified by the site operator.

- Consideration of the need to investigate further the form, distribution and persistence of tritium in the identified "footprint" around the Chapelcross site is being given consideration. This would including the measurement of OBT in environmental samples to underpin individual and collective dose assessments.