EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY

DIRECTORATE D – Nuclear energy, safety and ITER
D.3 – Radiation protection and nuclear safety

Verification under the terms of Article 35 of the Euratom Treaty

Technical Report

UNITED KINGDOM

Torness Nuclear Power Plant, Scotland

Monitoring of radioactive discharges to the environment

Environmental radioactivity monitoring programme

Environmental radioactivity monitoring network in the vicinity

24 – 27 October 2016

Reference: UK 16-04

VERIFICATIONS UNDER THE TERMS OF ARTICLE 35

OF THE EURATOM TREATY

FACILITIES	Torness Nuclear Power plant: - Facilities for monitoring and controlling discharges of gaseous and liquid radioactive effluents into the environment - The environmental radioactivity monitoring programme - Facilities for monitoring environmental radioactivity in the vicinity of power plant
LOCATIONS	Torness and Glasgow, Scotland
DATES	24 – 27 October 2016
REFERENCE	UK 16-04
TEAM MEMBERS	Mr Vesa Tanner, DG ENER (team leader) Mr Stefan Van der Stricht, DG ENER Mr Alan Ryan, DG ENER Mr Raf Van Ammel, DG JRC
REPORT DATE	3 January 2018
SIGNATURES	

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TECHNICAL REPORT

1 INTRODUCTION

Under Article 35 of the Euratom Treaty, all Member States must establish the facilities necessary to carry out continuous monitoring of the levels of radioactivity in air, water and soil and to ensure compliance with the basic safety standards[1]. Article 35 also gives the European Commission (EC) the right of access to such facilities to verify their operation and efficiency. The radiation protection and nuclear safety unit of the European Commission's Directorate-General for Energy is responsible for undertaking these verifications. The Joint Research Centre Directorate-General provides technical support during the verification visits and in drawing up the reports.

The main purpose of the verifications under Article 35 of the Euratom Treaty is to provide an independent assessment of the adequacy of monitoring facilities for:

- liquid and airborne discharges of radioactivity from a site into the environment;
- levels of environmental radioactivity at the site perimeter and in the marine, terrestrial and aquatic environment around the site, for all relevant exposure pathways;
- levels of environmental radioactivity on the territory of the Member State.

Taking into account previous bilateral protocols, a Commission Communication[2] describing practical arrangements for Article 35 verification visits in Member States was published in the *Official Journal of the European Union* on 4 July 2006.

2 PREPARATION AND CONDUCT OF THE VERIFICATION

2.1 Preamble

The Commission notified the United Kingdom (UK) of its decision to conduct an Article 35 verification in a letter addressed to the UK Permanent Representation to the European Union. The UK Government subsequently designated the Department of Business, Energy and Industry Strategy (BEIS) to lead the preparations for this visit.

2.2 Documents

To assist the verification team in its work, the UK national authorities supplied an information package in advance[3]. Additional documentation was provided during and after the visit. The information thus provided was used extensively in drawing up the descriptive sections of this report.

2.3 Programme of the visit

The EC and BEIS discussed and agreed on a programme of verification activities in line with the Commission Communication of 4 July 2006.

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1 Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (OJ L 159 of 29.6.1996) and Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation; repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom with effect from 6 February 2018. (OJ L 13 of 17.1.2014).

2 Commission Communication *Verification of environmental radioactivity monitoring facilities under the terms of Article 35 of the Euratom Treaty — Practical arrangements for the conduct of verification visits in Member States* (OJ C 155, 4.7.2006, pp. 2-5).

3 Replies to the preliminary information questionnaire addressed to the national competent authority, received on 5 October 2016.

The opening meetings held in Edinburgh and Torness NPP included presentations on the following:

- Radionuclide regulation in the UK
- Scottish Environment Protection Agency (SEPA)
- SEPA nuclear site regulation
- Office for Nuclear Regulation
- Food Standards Scotland
- SEPA Environmental radioactivity monitoring in Scotland
- Torness NPP site
- Torness NPP discharge monitoring
- Torness NPP environment monitoring

The verification team pointed to the quality and comprehensiveness of all the presentations and documentation. The team carried out the verifications in accordance with the programme in Annex 1. It met the following representatives of the national authorities and other parties involved:

Scottish Government

- Charles Stewart Roper, Team Leader, Radioactive Waste and Nuclear Decommissioning Policy Team
- Ewan Young, Policy Officer, Radioactive Waste and Nuclear Decommissioning Team

Scottish Environment Protection Agency (SEPA)

- Terry A'Hearn, Chief Executive
- David Pirie, Executive Director
- James Gemmill, Radioactive Substances Manager, Policy & Nuclear Regulation
- Isabelle Watson, Torness Site Inspector, Radioactive Substances Policy & Nuclear Regulation
- Paul Dale, Monitoring and Assessments, Radioactive Substances Policy & Nuclear Regulation
- Mark Toner, Monitoring and Assessments, Radioactive Substances Policy & Nuclear Regulation
- Corynne McGuire, Monitoring and Assessments, Radioactive Substances Policy & Nuclear Regulation

Food Standards Scotland (FSS)

- Will Munro, Higher Scientific Adviser, Chemical Radiological & Environmental Food Safety

Public Health England (PHE)

- Lesley Prosser, Head of Radiation Hazards and Emergencies Department
- Michael Davidson, Radiochemistry Group Leader, Radiation Hazards and Emergencies Department
- Charles Gow, Radiochemistry Team Leader, Radiation Hazards and Emergencies Department
- Gillian Clews, Radiochemistry Senior Analyst, Radiation Hazards and Emergencies Department

EDF Energy

- Alastair Brockie, Technical and Safety Support Manager
- Andrew Moodie, Environmental Safety Group Head
- Katharine Goan, Environmental Safety Engineer
- Brian White, Environmental Safety Engineer
- Radiochemistry Lab Technicians
- David Harris, Aitkens Team Leader
- Colin Sives, Aitkens District Survey Technician

Office for Nuclear Regulation (ONR)

- Marc Vannerem, Nominated Site Inspector, Torness and Principal Inspector, Nuclear Safety

3 LEGAL FRAMEWORK FOR RADIOACTIVITY MONITORING

3.1 LEGISLATIVE ACTS REGULATING ENVIRONMENTAL RADIOACTIVITY MONITORING

The United Kingdom, including Scotland, has comprehensive legislation covering radiation protection in general and radiological monitoring of the environment, foodstuffs and discharges in particular. The majority of the legislation has been adopted or updated recently. There are no legislative acts that explicitly regulate environmental radioactivity monitoring - monitoring is carried out under general environmental protection and improvement legislation.

The Environment Act 1995 gives SEPA the power to compile information relating to the state of the environment for the purpose of carrying out its functions or to enable it to form an opinion on the general state of the Scottish environment. The information that can be compiled can be that "acquired by SEPA carrying out observations" (i.e. environmental monitoring) or can be obtained in any other way (e.g. monitoring undertaken by others).

One of SEPA's functions is the administration of the Radioactive Substances Act 1993 using powers conferred by the Environment Act. The Scottish Government has issued the Radioactive Substances (Basic Safety Standards) Direction 2000 which requires that SEPA have regard to the certain requirements of the Euratom Basic Safety Standards Directive when discharging its functions under the Radioactive Substances Act. The requirements must have regard to optimisation of exposure to the public, dose limits, dose constraints and estimation of population doses. To be able to comply with this direction it is necessary to carry out an environmental monitoring programme under the powers provided by the Environment Act.

The specifications of the monitoring programme are agreed at a SEPA working group called the Environmental Radioactivity Monitoring Task Team (ERMTT). This group includes officials from SEPA, Scottish Government, Food Standards Scotland, the Food Standards Agency, Public Health England and Scottish Natural Heritage. This group ensures that the environmental radioactivity monitoring programme satisfies the legislative requirements, including UK obligations in Scotland under the Euratom Treaty.

3.2 LEGISLATIVE ACTS REGULATING MONITORING OF RADIOACTIVE DISCHARGES

The Radioactive Substances Act 1993 (RSA93) requires prior authorisation of radioactive discharges. The Environment Act 1995 gives powers to grant authorisations of radioactive discharges to the new environment agencies that were formed under the Act. As a consequence SEPA is the appropriate agency to administer the requirements of the RSA93 in Scotland.

In giving prior authorisation for the discharge of radioactive materials RSA93 allows SEPA and the appropriate Minister to attach conditions and limitations to the authorisation as appropriate. Following the Scotland Act of 1998, the subject of radioactive waste regulation was largely devolved and the appropriate Minister referred to in RSA93 became the Scottish Minister.

In considering whether to grant a discharge authorisation for a nuclear facility SEPA consults with Scottish Ministers on the intended limitations and conditions. SEPA has a number of standard conditions for authorisations, some of which address discharge monitoring. The relevant conditions are:

- *"The Authorisation Holder shall take samples and conduct measurements, tests, surveys, analyses and calculations to determine its compliance with the limitations and conditions of this Authorisation."*
- *"The Authorisation Holder shall use the best practicable means when taking samples and conducting measurements, tests, surveys, analyses and calculations to determine its compliance with the limitations and conditions of this Authorisation, unless particular means are specified in this Authorisation."*

3.3 INTERNATIONAL LEGISLATION AND GUIDANCE DOCUMENTS

The list below includes the main international legislation and guidance documents issued by the European Union (EU) and the International Atomic Energy Agency (IAEA) that form the basis for environmental radioactivity monitoring, the radiological surveillance of foodstuffs and the radiological surveillance of radioactive discharges.

The European Union

- The Euratom Treaty (1957)
- Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (OJ L 159 of 29.6.1996)
- Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation; repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom with effect from 6 February 2018. (OJ L 13 of 17.1.2014)
- Council Directive 2013/51/Euratom of 22 October 2013 laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption (OJ L 296 of 7.11.2013)
- Commission Recommendation 2000/473/Euratom of 8 June 2000 on the application of Article 36 of the Euratom Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole (OJ L191 of 27.7.2000)
- Commission Recommendation 2004/2/Euratom of 18 December 2003 on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation (OJ L36 of 6.1.2004)

International bodies, in particular the International Atomic Energy Agency (IAEA)

- *Radiation Protection and Safety of radiation Sources: International Basic Safety Standards*, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna, 2014
- *Clearance of materials resulting from the use of radionuclides in medicine, industry and research*, IAEA-TECDOC-1000, IAEA, Vienna, 1998
- *Generic models for use in assessing the impact of discharges of radioactive substances to the environment*, Safety Reports Series No 19, IAEA, Vienna, 2001
- *Handbook of parameter values for the prediction of radionuclide transfer in temperate environments*, Technical Reports Series No 364, IAEA, Vienna, 1994
- *International basic safety standards for protection against ionizing radiation and for the safety of radiation sources*, Safety Series No 115, IAEA, Vienna, 1996
- *Management of radioactive waste from the use of radionuclides in medicine*, IAEA-TECDOC-1183, IAEA, Vienna, 2000
- *Regulatory control of radioactive discharges to the environment: Safety Guide*, Safety Standards Series No. WS-G-2.3, IAEA, Vienna, 2000

International conventions

- The Convention on Nuclear Safety
- The Convention on Early Notification of a Nuclear Accident
- The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

4 BODIES HAVING COMPETENCE IN THE FIELD OF ENVIRONMENTAL AND DISCHARGE RADIOACTIVITY MONITORING

4.1 NATIONAL COMPETENCE IN THE UNITED KINGDOM

4.1.1 Introduction

The United Kingdom is a union between England, Northern Ireland, Scotland and Wales. When the term ‘UK Government’ is used in this document it refers to the Government at Westminster, responsible for all matters relating to England and for those matters where powers of decision-making have not been given to the three devolved administrations of Northern Ireland, Scotland or Wales. These matters are known as ‘reserved’ as they are taken by the UK Parliament at Westminster even though they have effect in Northern Ireland, Scotland and Wales as well as England. Examples of reserved matters include nuclear security and nuclear safety.

Conversely some matters are devolved as decision-making is the responsibility of the Scottish Parliament, the Welsh Assembly and the Northern Ireland Assembly, rather than the Government at Westminster. Examples of devolved matters include the environment. As some matters are devolved, this can create the potential for some differences in the way that certain regulations are enacted in law. Examples include the Environmental Permit Regulations 2010 (England and Wales) and the Radioactive Substances Act 1993 (Scotland and Northern Ireland) in regard to environmental permitting.

The UK Government represents England, Northern Ireland, Scotland and Wales in international fora acting as the responsible overall authority, including at the EU, EURATOM, IAEA and the OECD Nuclear Energy Agency (NEA).

4.1.2 Department of Business, Energy and Industry Strategy

The Department of Business, Energy and Industry Strategy (BEIS) brings together responsibilities for business, industrial strategy, science, innovation, energy, and climate change. It is responsible for developing industrial strategy and leading the UK government’s relationship with business, ensuring that the UK has secure energy supplies that are reliable, affordable and clean, ensuring that the UK remains at the leading edge of science, research and innovation and tackling climate change. BEIS is the overall responsible authority in the UK for environmental radioactivity monitoring and nuclear and radiological emergency preparedness.

4.1.3 Department for Environment, Food and Rural Affairs

The Department for Environment, Food and Rural Affairs (DEFRA) is the UK government department responsible for safeguarding natural environment, supporting food and farming industry and sustaining a thriving rural economy. DEFRA is a ministerial department, supported by 33 agencies and public bodies. It is the overall responsible authority in the UK for radiological surveillance of food.

4.1.4 Office for Nuclear Regulation

The Office for Nuclear Regulation (ONR) regulates nuclear safety and security at 36 nuclear licensed sites in the UK. It also regulates transport and ensures that safeguards obligations for the UK are met. ONR also oversees the decommissioning of nuclear sites and cooperates with international regulators on safety and security issues of common concern, including associated research. ONR was established as a statutory Public Corporation on 1 April 2014 under the Energy Act 2013, which provides the framework of responsibilities and the powers of the organisation.

4.2 REGIONAL COMPETENCE IN SCOTLAND

4.2.1 Introduction

The Scottish Government was established under the Scotland Act 1998, which devolved the responsibility for environmental protection, including the Radioactive Substances Act 1993 (RSA93). It has a number of policy areas which have roles in monitoring and responses to nuclear and radioactivity issues in Scotland. These include monitoring or radioactivity in the environment, food and discharges and preparedness for radiological emergency situations.

4.2.2 Scottish Environment Protection Agency

The Scottish Environment Protection Agency (SEPA) is a non-departmental public body, accountable through Scottish Ministers to the Scottish Parliament. It was established by the Environment Act 1995 (EA95) and has the responsibility for implementing and enforcing environmental legislation including the provisions of the RSA93. SEPA's responsibilities in this domain are as set out in the EA95 section 3.1.

SEPA was formed from a large number of predecessor bodies regulating environmental pollution and waste management of all types, not only radioactive substances. This merger gave SEPA additional strength by bringing together many specialisms and permitting the regulation of radioactive substances to be carried out in an integrated fashion within the constraints of the legislative and policy framework set by the government.

SEPA’s main duty is to protect the environment by controlling pollution to land, air and water in Scotland. This includes radioactive substances: regulating the use and disposal of radioactive substances, holding the national register for the use and disposal of radioactive substances, controlling discharges of radioactive waste from nuclear installations and managing the UK Radiation Incident Monitoring Network (RIMNET) in Scotland.

The environmental monitoring programme undertaken by SEPA is a unified programme in which the combined exposure pathways resulting from radioactive substances in the environment and foodstuffs are considered together. The programme is developed and reviewed by a SEPA Project Group – the Environmental Radioactivity Monitoring Task Team (ERMTT).

4.2.3 Food Standards Scotland

The Food Standards Scotland (FSS) is the public sector food body for Scotland. It was established by the Food (Scotland) Act 2015 as a non-ministerial office, and a part of the Scottish Administration, alongside, but separate from the Scottish Government. FSS is the competent authority for food safety in Scotland, including radioactivity in food.

4.2.4 East Lothian Council

The East Lothian Council is a regional administration of the Torness NPP surrounding area, which has responsibilities under the Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR). It undertakes its own radiological monitoring around the Torness NPP.

5 TORNESS NPP SITE AND ITS RADIOLOGICAL SURVEILLANCE PROGRAMME

5.1 SITE DESCRIPTION

The Torness nuclear power plant (TNPP) is located to the south-east of the town of Dunbar, on the coastal strip facing the North Sea (Thortonloch Bay area). TNPP is operated by the EDF Group and houses two Advanced Gas-cooled Reactors (AGR). Construction began in 1980 and the station started generating electricity in 1988. The station's electrical output capability is 1215 MWe (685 MWe per unit). TNPP is planned to operate until at least 2030.

TNPP discharges its liquid radioactive effluents, via the TNPP cooling water outfall, into the North Sea. Prior to discharge, the effluent has been processed not only to minimise the amounts of radioactivity therein but also to abide by the regulatory discharge limits and conditions.

The table below presents the characteristics of the plant and the AGR technology.

Fuel	Enriched uranium dioxide pellets (~3% enrichment) 64 pellets in stainless steel fuel pin 36 pins per fuel element 8 fuel elements in a fuel assembly 1 fuel assembly per fuel channel 332 fuel channels	
Reactor Core	Core	Graphite (as moderator and having a structural role)
	Coolant	Carbon dioxide pressure: 40bar Gas inlet temperature: 295°C Gas outlet temperature: 640°C
	Pressure vessel	Steel-lined pre-stressed concrete

5.2 OPERATOR'S ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

The main sources of possible contamination of the environment that may result from normal TNPP operations are the discharges of airborne and liquid radioactive effluents. Under RSA93 such discharges are subject to regulatory limits and conditions.

Document ENL/REP/0007/AGR/06 – Review of the Environmental Monitoring Programme for TNPP, in function of the type of discharge, to atmosphere (and subsequent terrestrial deposition) or into the marine environment, defines the types of samples (and associated laboratory analyses) that are to be taken (performed) in the framework of the ERMP. This is further elaborated upon in the TNPP Station Procedure TSP/RWM/009 so as to ensure that the ERMP meets the requirements of the TNPP Radioactive Substances Act Discharge Authorisation under RSA93 (Section 2.3.2 RSA/A/0070116).

The aim of the ERMP is to measure the levels of activity within the surrounding environment. Knowledge of these levels allows assessment of the TNPP radiological impact on the local and wider environment. It also provides the background level against which the significance of any unanticipated release of radioactive effluents can be assessed.

The results of the programme are reported quarterly to SEPA in Edinburgh and Generation Environment Management (GEM) in Barnwood. GEM collates all of the fleet data and provides oversight.

The terrestrial samples are taken from specific areas outside of Torness; the land is divided into three regions (West, South West and South East) and three ranges (Inner Ring: 1-5 km; Outer Ring: 5-10 km; Control Ring: >10 km). These ranges are also used for the marine samples split into North and South regions.

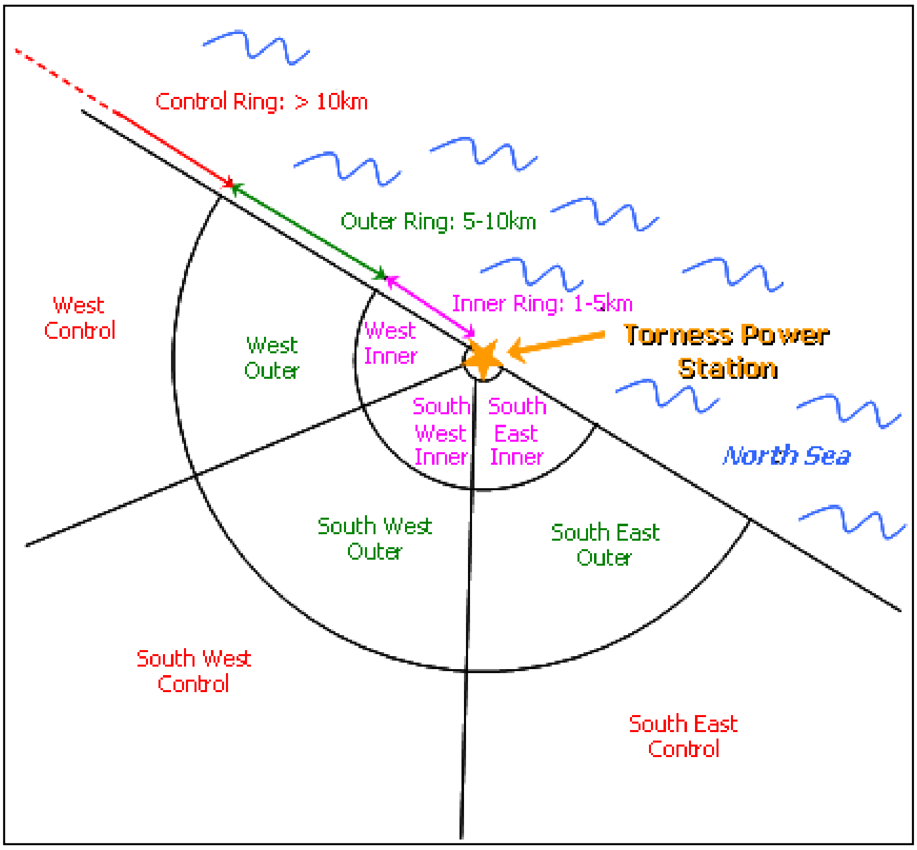

Figure 1. Sampling areas of the TNPP ERMP

The sampling/monitoring locations are all within the zones/bands detailed above. The general areas are shown on Fig. 2 below.

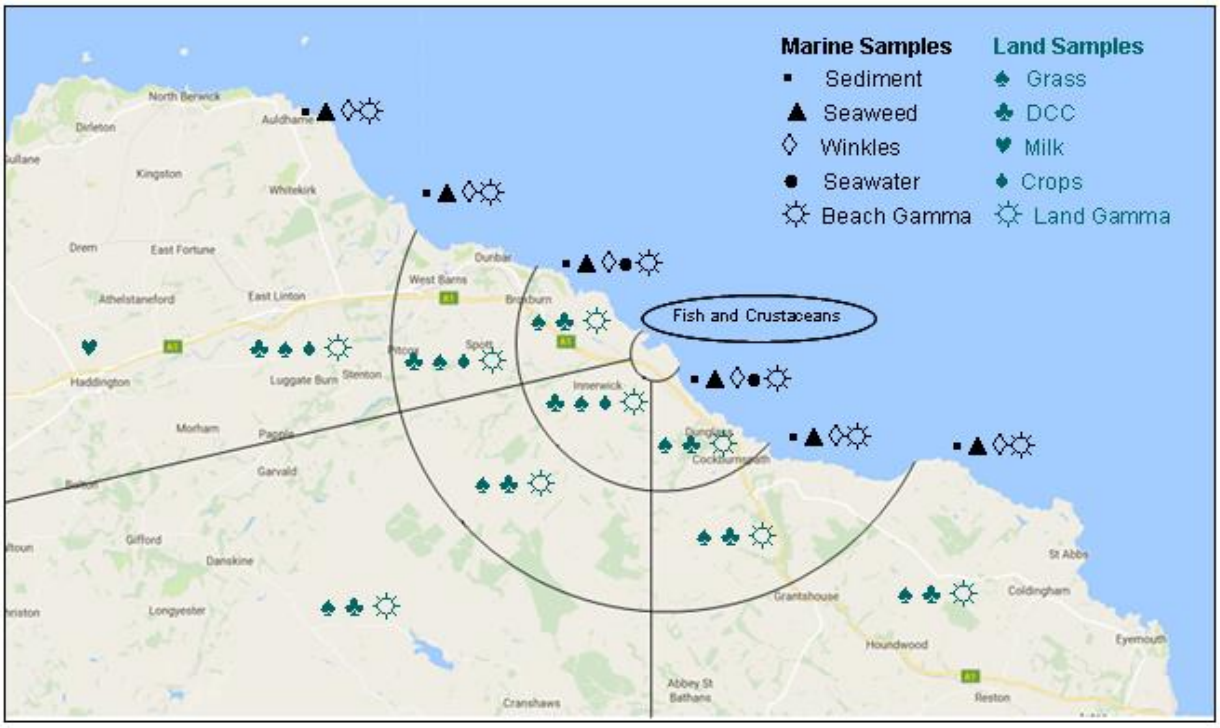

Figure 2. Sampling locations and types of samples taken inside the TNPP ERMP

Dry cloth collectors (DCCs) are collected monthly; all other samples are collected either quarterly or annually as summarised in the table below:

1st month of Quarter	2nd month of Quarter	3rd month of Quarter	Annual Samples
DCC	DCC	DCC	Apples
Land Gamma	Grass	Any samples not obtained in the 1st and 2nd quarter	Potatoes
Beach Gamma	Any samples not obtained in the 1st Quarter		Soils (on quinquennial rotation)
TLDs			
Seaweed			
Sediment			
Winkles			
Seawater			
Milk			

Other samples obtained but not collected by the TNPP Environment Safety Group (ESG) are fish, crab, lobster and prawns. These are supplied by local fishermen to ensure that the landings are obtained from the Thortonloch bay area. Local fishing equipment is also surveyed on an annual basis: a selection of nets, creels and lobster pots are measured for potential β/γ and γ dose rate that would result from contamination.

The table below presents a detailed overview of the operator district survey analysis. Findings and results are compiled in quarterly reports.

Sample	Number of samples	Frequency	Procedure	Radionuclide	Other analysis
DCCs	20 (on and off site)	Monthly	Cloths are grouped by zone and counted on the gamma spectrometer	^{60}Co, ^{134}Cs and ^{137}Cs, other gamma ^{40}K, ^{7}Be and ^{235}U	-----
Land gamma	22 locations	Quarterly	Geiger-Müller tube reading at 1m	γ dose rate (in μGy/h)	-----
Beach gamma	6 locations	Quarterly	Geiger-Müller tube reading at 1m	γ dose rate (in μGy/h)	-----
Grass	9 locations	Quarterly	2 kg wet sample (sample location recorded)	^{60}Co, ^{134}Cs and ^{137}Cs, any other γ, ^{35}S and ^{131}I	Annual ^{14}C analysis
Milk (*)	1 location	Quarterly	5 litre sample (direct from dairy farm)	Gross β, ^{35}S and ^{60}Co, ^{134}Cs and ^{137}Cs, any other γ	Annual ^{14}C analysis
Apples	3 locations	Annually	3 kg sample (collected from the tree)	^{35}S and ^{60}Co, ^{134}Cs and ^{137}Cs, any other γ	Annual ^{14}C analysis
Potatoes	3 locations	Annually	3 kg sample, collected from the field or farm shop	^{35}S and ^{60}Co, ^{134}Cs and ^{137}Cs, any other γ	Annual ^{14}C analysis
Seaweed	6 locations	Quarterly	4 kg wet sample	Gross β and γ, including ^{60}Co, ^{54}Mn, ^{110m}Ag and ^{137}Cs	-----
Sediment	6 locations	Quarterly	2 kg sample	Gross β and γ, including ^{60}Co, ^{54}Mn, ^{110m}Ag and ^{137}Cs	Annual α analysis

Sample	Number of samples	Frequency	Procedure	Radionuclide	Other analysis
Winkles (*)	7 locations	Quarterly	1 bucket	Gross β and γ, including ^{60}Co, ^{54}Mn, ^{110m}Ag and ^{137}Cs	-----
Seawater	2 locations and Outfall checked monthly	Quarterly	1 litre	^{3}H, total β and γ, including ^{60}Co, ^{54}Mn, ^{110m}Ag and ^{137}Cs	-----
Gadoid fish (*)	1 location	Quarterly	3-4 kg of fish to allow for 2 kg of flesh	Gross β and γ, including ^{60}Co, ^{54}Mn, ^{110m}Ag and ^{137}Cs	-----
Dermal fish (*)	1 location	Quarterly	3-4 kg of fish to allow for 2 kg of flesh	Gross β and γ, including ^{60}Co, ^{54}Mn, ^{110m}Ag and ^{137}Cs	-----
Lobster (*)	1 location	Quarterly	4	Gross β and γ, including ^{60}Co, ^{54}Mn, ^{110m}Ag and ^{137}Cs	-----
Prawns (*)	1 location	Quarterly	0.5-1 kg, everything processed	Gross β and γ, including ^{60}Co, ^{54}Mn, ^{110m}Ag and ^{137}Cs	-----
Crab (*)	1 location	Quarterly	10	Gross β and γ, including ^{60}Co, ^{54}Mn, ^{110m}Ag and ^{137}Cs	-----
TLD (**)		Quarterly	TLD removed from holder and sent off site for analysis		

(*) Sample analysis results are used to calculate the effective dose (in µSv/year) to the most exposed local population, results are reported quarterly.

(**) TLDs are maintained for Emergency Plan Management (TLDs are not part of the REMP). The data obtained are sent to Office of Nuclear Regulation (ONR).

5.3 REGULATOR'S ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

The regulator's ERMP around the Torness NPP covers the marine, terrestrial and atmospheric environment. Public Health England (PHE), Centre for Radiation, Chemical and Environmental Hazards laboratory at Glasgow (CRCE Glasgow), is the current commercial contractor for this work and undertakes the sampling and analysis operations as well as the calibration and maintenance of monitoring equipment where required.

CRCE staff collects samples directly from the environment or from dedicated suppliers. The sample collection methodology is laid down in a set of operating procedures, e.g. CRCEG TM 6.1 (General sampling procedures), CRCEG TM 6.3 (Soil sampling), CRCEG TM 6.4 (Sediment sampling), CRCEG TM 6.5 (Grass sampling), CRCEG TM 6.6 (Water sampling), CRCEG TM 6.7 (Shellfish sampling), CRCEG TM 6.8 (Seaweed sampling) etc. PHE must ensure that every individual sample is assigned a unique reference number. This number is used to identify the complete sample record, recording all sampling, preparation and analysis details. This system provides SEPA with a complete traceability chain from collection to reporting.

Continuous air sampling is undertaken at three locations around Torness. These samplers are calibrated by Munro Instruments (sampler manufacturer) and maintained by PHE with support as required from Munro Instruments.

The regulator's ERMP as carried out by PHE is detailed in the table below. Analysis requirements are detailed for samples that are not dose rates or strandline measurements.

Zone	Location	NGR	Measurement	Frequency	Analysis
MARINE	RNLI Compound	NT 7472 7550	Beta Dose Rate	Biannual	-----
	Barns Ness	NT 7196 7724	Gamma Dose Rate	Biannual	------
	Belhaven Bay	NT 6613 7867	Gamma Dose Rate	Biannual	------
	Coldingham Bay	NT 9174 6655	Gamma Dose Rate	Biannual	------
	Dunbar Inner Harbour	NT 6809 7925	Gamma Dose Rate	Biannual	------
	Heckies Hole	NT 6341 8057	Gamma Dose Rate	Biannual	------
	Pease Bay	NT 7931 7108	Gamma Dose Rate	Biannual	------
	Skateraw	NT 7388 7538	Gamma Dose Rate	Biannual	------
	St Abbs	NT 9192 6742	Gamma Dose Rate	Biannual	------
	Thornton Loch	NT 7522 7461	Gamma Dose Rate	Biannual	------
	Barns Ness	NT 7263 7649	Gamma Strandline	Annual	------
	Pease Bay	NT 7921 7098	Gamma Strandline	Annual	------
	Skateraw	------	Gamma Strandline	Annual	------
	Thornton Loch	------	Gamma Strandline	Annual	------
	PLZ	Supplier	Seafood - Bass	Biannual	γ spectrometry
	White Sands	Supplier	Seafood - Cod	Biannual	γ spectrometry
	RNLI Compound	NT 7472 7550	Seafood - Crab	Annual	γ spectrometry, ^{99}Tc, ^{14}C
	RNLI Compound	NT 7472 7550	Seafood - Lobster	Annual	γ spectrometry, ^{99}Tc, ^{14}C
	Dunbar	Supplier	Seafood - Nephrops	Biannual	γ spectrometry, ^{241}Am, $^{238/239}Pu$
	PLZ	NT 7525 7492	Seafood - Winkles	Biannual	γ spectrometry, total α, total β
	PLZ	NT 7532 7492	Seawater	Biannual	γ spectrometry, ^{3}H, ^{35}S and salinity
	Coldingham Bay	NT 9174 6668	Seaweed	Biannual	γ spectrometry
	Pease Bay	NT 7931 7108	Seaweed	Biannual	γ spectrometry
	PLZ	NT 7525 7488	Seaweed	Biannual	γ spectrometry
	Thornton Loch	NT 7522 7461	Seaweed	Biannual	γ spectrometry, ^{99}Tc, ^{14}C
	White Sands	NT 7160 7734	Seaweed	Biannual	γ spectrometry
	Barns Ness	NT 7196 7724	Sediment	Annual	γ spectrometry
	Belhaven Bay	NT 6611 7868	Sediment	Annual	γ spectrometry
	Coldingham Bay	NT 9174 6668	Sediment	Annual	γ spectrometry
	Dunbar	NT 6809 7924	Sediment	Annual	γ spectrometry
	Heckies Hole	NT 6341 8057	Sediment	Annual	γ spectrometry
	Pease Bay	–	Sediment	Annual	γ spectrometry

Zone	Location	NGR	Measurement	Frequency	Analysis
	Thornton Loch	NT 7521 7465	Sediment	Annual	γ spectrometry
TERRESTRIAL	3 Farms	Suppliers	Milk	–	γ spectrometry, ^{3}H, ^{14}C, ^{90}Sr, ^{35}S
	3 Locations	-------–	Grass	Annual	γ spectrometry, ^{3}H, ^{14}C, total α, total β, ^{90}Sr, ^{35}S
	3 Locations	-------–	Soil	Annual	γ spectrometry, ^{3}H, ^{14}C, total α, total β, ^{90}Sr, ^{35}S
	3 Locations	-------–	Gamma Dose Rate	Annual	-------–
	-------–	Suppliers	Locally Grown Produce	As available	γ spectrometry, ^{3}H, ^{14}C, ^{90}Sr, ^{35}S
	Hope Reservoir	NT 5501 6203	Freshwater	Annual	γ spectrometry, ^{3}H, total α, total β
	Thorters Reservoir	NT 6045 6960	Freshwater	Annual	γ spectrometry, ^{3}H, total α, total β
	Whiteadder	NT 6463 6415	Freshwater	Annual	γ spectrometry, ^{3}H, total α, total β
	Burn at Thortonloch Bridge	NT 7418 7410	Freshwater	Annual	γ spectrometry, ^{3}H, total α, total β
	Torness	Supplied by the site	Effluent	Quarterly	γ spectrometry, ^{3}H, total α, total β, ^{90}Sr, ^{35}S
AIR	Cocksburn Path	NT 7751 7171	Air	Monthly	γ spectrometry, total α, total β
	Innerwick	NT 7252 7384	Air	Monthly	γ spectrometry, total α, total β
	West Barns	NT 6508 7809	Air	Monthly	γ spectrometry, total α, total β

For each of these samples the detection limits are detailed in the 3 tables below:

- Marine samples:

Analysis	Detection limit
Gamma spectrometry – all positively identified radionuclides within energy range of 20 – 2000 keV must be reported. In addition, results for all of the following radionuclides must also be reported (positive results and those < minimum detectable activity): ^{54}Mn, ^{58}Co, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{95}Zr, ^{95}Nb, ^{106}Ru, ^{110m}Ag, ^{125}Sb, ^{134}Cs, ^{137}Cs, ^{144}Ce, ^{154}Eu, ^{155}Eu, ^{241}Am, ^{40}K	^{60}Co: 0.1 Bq/kg or Bq/l
^{3}H	1.0 Bq/kg or Bq/l
Alpha spectrometry of isotopes of Pu and Am	0.0001 Bq/kg or Bq/l
^{90}Sr	0.1 Bq/kg or Bq/l
^{14}C	15 Bq/kg or Bq/l (*)
^{99}Tc	0.05 Bq/kg or Bq/l
^{241}Pu	0.1 Bq/kg or Bq/l
^{210}Pb	0.01 Bq/kg or Bq/l
Total Beta (as ^{137}Cs)	0.1 Bq/kg or Bq/l

(*) Results should also be reported as Bq per gram of carbon (Bq/g^{14}C)

- Terrestrial samples

Analysis	Milk	Grass	Soil	Locally grown produce	Freshwater
	Bq/l	Bq/kg	Bq/kg	Bq/kg	Bq/l
Gamma spectrometry. The following radionuclides are to be routinely reported: ^{60}Co, ^{95}Zr, ^{95}Nb, ^{106}Ru, ^{103}Ru, ^{110m}Ag ^{134}Cs, ^{137}Cs, ^{144}Ce, ^{40}K. Other nuclides need only be reported if positive measurements are obtained.	0.05	0.05	0.05	0.05	0.01
^{3}H	5	5	5	5	1
^{14}C	15	15	---–	15	---–
^{35}S	0.5	0.5	---–	0.5	---–
^{90}Sr	0.1	0.1	0.1	0.1	---–
^{129}I	---–	0.05	0.05	0.05	---–
^{241}Am	---–	0.05	0.05	0.05	---–
$^{238/239/240}Pu$	---–	0.05	0.05	0.05	---–
Total α	---–	0.01	0.01	---–	0.01
Total β	---–	0.01	0.01	---–	0.01
$^{234/235/238}U$	---–	0.05	0.05	0.05	---–

- Air samples

Analysis	Detection limit (μBq/m^3)
Total α	5
Total β	200
Gamma spectrometry (^{137}Cs)	10

The maps below show SEPA’s TNPP-related environmental radioactivity sampling sites (Figure 3) and the environmental radioactivity sampling sites in the wider area around TNPP (Figure 4). Note that at a number of locations multiple samples are collected from the same sampling point and as such will be overlapping on the images.

Furthermore SEPA undertakes a comprehensive monitoring programme across Scotland as depicted on Figure 5.

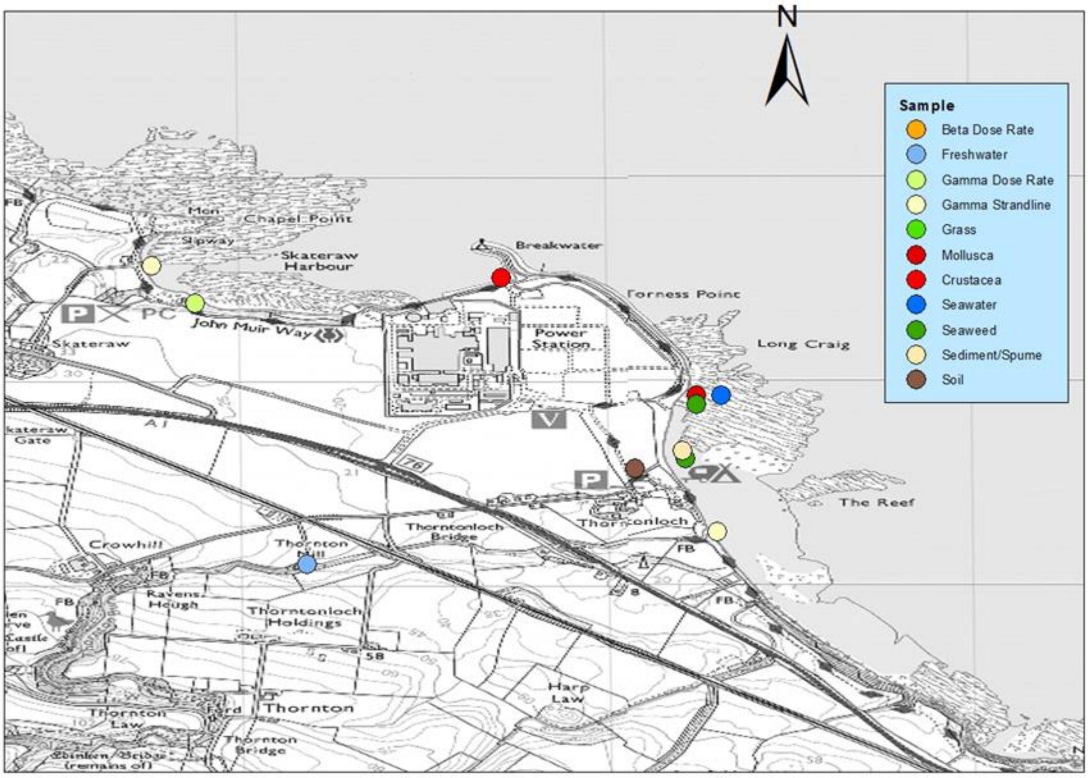

Figure 3. SEPA environmental radioactivity sampling sites in the TNNP vicinity

Figure 4. SEPA environmental radioactivity sampling sites in the wider area around TNPP

Figure 5. SEPA Scotland-wide sampling locations

5.4 MONITORING OF EXTERNAL DOSE AND DOSE RATE

In Scotland, there are two primary programmes of gamma dose rate monitoring. One of these is directly related to the nuclear licensed sites. The programme forms part of the site radiological surveillance programme. This aspect is regulated by the Office for Nuclear Regulation as outlined below. The second programme is to assess general levels across the UK and provide an early warning system distant from nuclear licensed sites.

5.4.1 NPP dose monitoring

The duty for ensuring that public doses due to ionising radiation are controlled and comply with the relevant dose limits rests with the nuclear site licensee. For Torness this is EDF. ONR has regulatory responsibility, along with other regulators in the UK, for enforcement of the dose limits. ONR has regulatory responsibility for the direct radiation pathway. They have an ongoing intervention to consider how the nuclear site licensees comply. Information on public dose from this pathway is provided on an annual basis to ONR by all licensees. ONR considers this information and identifies a sample of sites for further examination each year; usually 3-4 per year. The examination takes the form of confirmatory measurements undertaken by Public Health England (PHE) under contract to ONR. These confirmatory measures are used to identify sites for further inspection if required. The last confirmatory measurements at Torness were taken in 2012. The report provided to ONR of the work conducted by PHE confirmed the data provided by EDF. Neither the results provided by EDF nor PHE gave rise to any concern so further work has not been undertaken at Torness. If, however, after receiving the licensee's data on site perimeter measures differences between the licensee's and PHE monitoring results are identified, ONR will inspect the site arrangements to reconcile these differences.

5.4.2 EDF public dose monitoring

For direct radiation shine EDF Energy reports an assessed annual contribution to two groups of people living around the power station. These groups are an "all pathways exposure" representative person and a most exposed group for that pathway. Doses for the "all pathways exposure" representative person are assessed as <10 µSv/year and doses for the most exposed group for that pathway are assessed as <20 µSv/year. The assessment includes gamma, neutron and X-ray, but the precision of the estimate does not justify a breakdown into separate contributions.

Dose rates around Torness are generally very low and hard to distinguish from natural background which varies spatially and fluctuates with time. Any measurement made around the site will include a contribution for discharges which typically contain ^{41}Ar.

5.4.3 Site boundary dose monitoring

In order to confirm that there is no significant change to the dose assessment Thermo Luminescent Dosimeters (TLD's) are positioned around the perimeter of the site. The locations of the TLD's are shown in Figure 6.

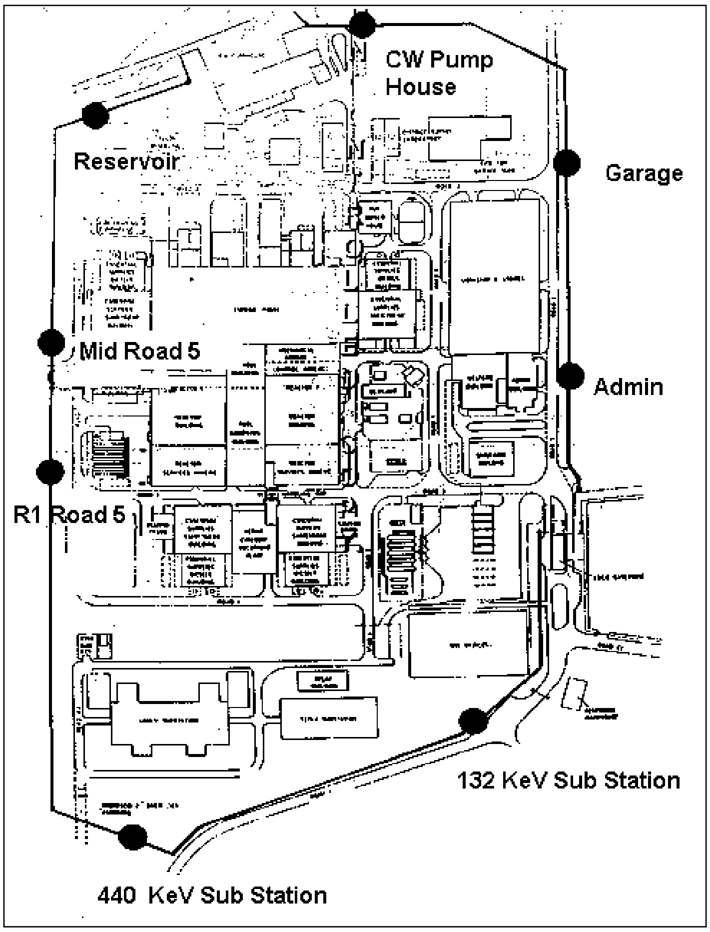

Figure 6. Locations of the TNNP site boundary TLD's

The TLD used is a Harshaw (LiF doped with trace quantities of Mg and Ti) (Fig. 7). The TLD has 4 identical elements and the reading is an average of these. The TLD is deployed in a holder (Fig. 8) which ensures that the TLD meets the requirements for measuring ambient dose equivalent H*(10) by maintaining correct positioning of the TLD in relation to the local environment.

The system of TLD and TLD-reader is calibrated in terms of ambient dose equivalent. Any instrument or source used in the process is traceable to the UK national standards (National Physical Laboratory, NPL). This is managed and carried out at Berkeley (UKAS Accredited Lab). The measurement period in the field is 3 months (TLDs are changed in Jan., Apr., Jul. and Oct.).

Figure 7. Harshaw TLD

Figure 8. Seibersdorf TLD holder

EDF receives a quarterly report from Berkeley which details the gross result for each TLD which includes the deployed and the control TLD's. The data is then entered into a spreadsheet which records on-off dates, calculates the number of days and then converts the gross data to a daily dose rate. The gross on-site (perimeter fence) results are reported to ONR.

5.4.4 Site boundary dose rate monitoring

As part of the site's emergency response there is a system designed to give warning of the discharge of a radioactive plume. This is done by measuring the dose rate at fixed positions around the site perimeter. Alarms are brought up in the Central Control Room which is manned 24/7; the data is also available in the site Emergency Control Centres.

The system was supplied and is supported by Ultra Electronics. Each monitoring point has 2 Geiger-Müller (GM) detector tubes to cover low and high dose rates. Both detectors operate continuously. The location of the detectors is shown in Figure 9.

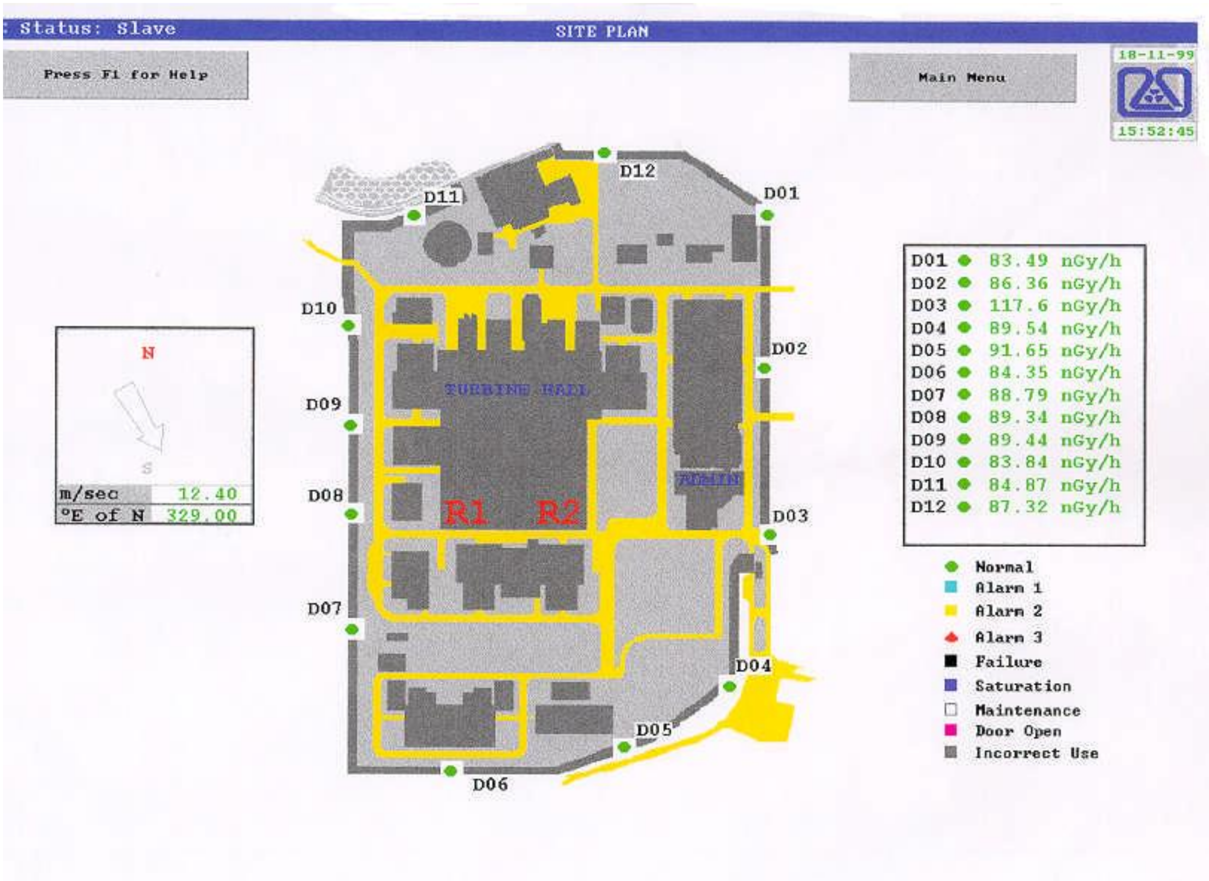

Figure 9. Location of site boundary monitors

The contract with Ultra Electronics includes an annual service visit. Station maintenance can carry out first line maintenance and diagnostics but more detailed work would require support from the supplier. ESG carries out an annual source check using instruction HPS/IE/010(W).

The dose rate monitoring network uses a 9205 EMS Data Management System which is a SCADA (supervisory control and data acquisition) system designed to receive and log live data from a distributed network of radiation monitors. It uses a commercial off the shelf VTScada platform configured for Torness requirements.

The system comprises a number of data display screens including Facility/Site Plan, Status Matrix, Alarm Page and Historical Data Viewer. In addition it supports features such as data export, report generation, multiple user access modes and data archiving. It can also be implemented across a company-wide intranet/extranet, where data from multiple networks systems can be accessed at a central terminal.

5.4.5 Gamma dose rate monitoring distant from the NPP

The Radiation Incident Monitoring Network (RIMNET) alerting system is operated by the Meteorological Office on behalf of BEIS. Set up as a response to the Chernobyl accident, every hour the system collects radiation dose rate readings from 96 fixed location sites across the United Kingdom. Background radiation is the main component of observed levels of gamma radiation recorded at RIMNET sites. The observed UK radiation dose ranges from 0.5 to 1.0 mSv/year with an average of less than 0.7 mSv/year. Measurement results can be downloaded from the BEIS website[4].

RIMNET monitoring stations are normally located at some distance from nuclear sites, mainly in order to ensure that results are not sensitive to variations in authorised discharges from nuclear sites.

5.5 MONITORING OF AIR

5.5.1 SEPA air sampling networks

In Scotland, there are two networks that monitor radioactivity in air by continuous sampling. The first is part of the radiological surveillance programmes directly related to the Scottish nuclear licensed sites and consists of medium-volume air samplers (MVAS). The second is the Scotland-wide network, the samplers of which are situated away from nuclear licensed sites. This latter network of three high-volume air samplers (HVAS) provides data on the general levels of radioactivity in air in Scotland. HVAS samplers are located in Eskdalemuir, Glasgow (Holytown) and Lerwick. All samplers are fitted with polypropylene multi-layer particulate filters that retain up to 99% of airborne particles having a diameter of ≥ 1 µm. Sampling locations are shown in Figure 10 and 11 (TNPP vicinity).

The HVAS are of the type *Hi Vol 3000* manufactured by Ecotech[5] (at Holytown and at Lerwick) and of the type *HVP-4300AFC* manufactured by Hi Q[6] (at Eskdalemuir). The MVAS are of the type L60 manufactured by Munro Instruments.

Calibration of these instruments is carried out annually. All samplers are serviced (monthly filter exchanges and subsequent laboratory analysis of the filters – gamma spectroscopy, gross alpha and gross beta) and maintained by CRCE Glasgow, SEPA's current commercial contractor.

The Lerwick and Eskdalemuir instruments are based at meteorological observation stations operated by the UK Meteorological Office. The Holytown device is located at SEPA office premises. The HVAS are checked on a daily basis by the resident staff, which are trained in the operation and reset procedures should a sampler fail. The monthly filter changes are also performed by local staff and the retrieved filters posted to CRCE Glasgow for laboratory analysis. Filters are analysed with gamma-ray spectroscopy and measured for gross alpha and gross beta.

There are a number of steps that are employed to provide a check during the period between monthly filter changes:

- Whilst in the area for carrying out other samplings, CRCE staff is required to check the operation of the air samplers and take action if necessary.
- The air samplers have been fitted with surge protectors and have been programmed to attempt to restart in the event of a failure.
- Local arrangements are in place to ensure the units are checked frequently and either attempts are made to restart the equipment or notify the SEPA contractor if a unit has failed.

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[4] https://www.gov.uk/government/publications/ambient-gamma-radiation-dose-rates-across-the-uk

[5] Technical data: www.ecotech.com/product/particulates/ambient/hivol-3000-high-volume-air-sampler

[6] Technical data: http://www.hi-q.net/products/outdoor-high-volume-air-samplers/4000-series-automatic-flow-control-high-volume-tsp-with-communication-options/default.html

- The units log the runtime and other properties which can be checked to see if there is a pattern of failures.

Figure 10. SEPA air sampling locations across Scotland

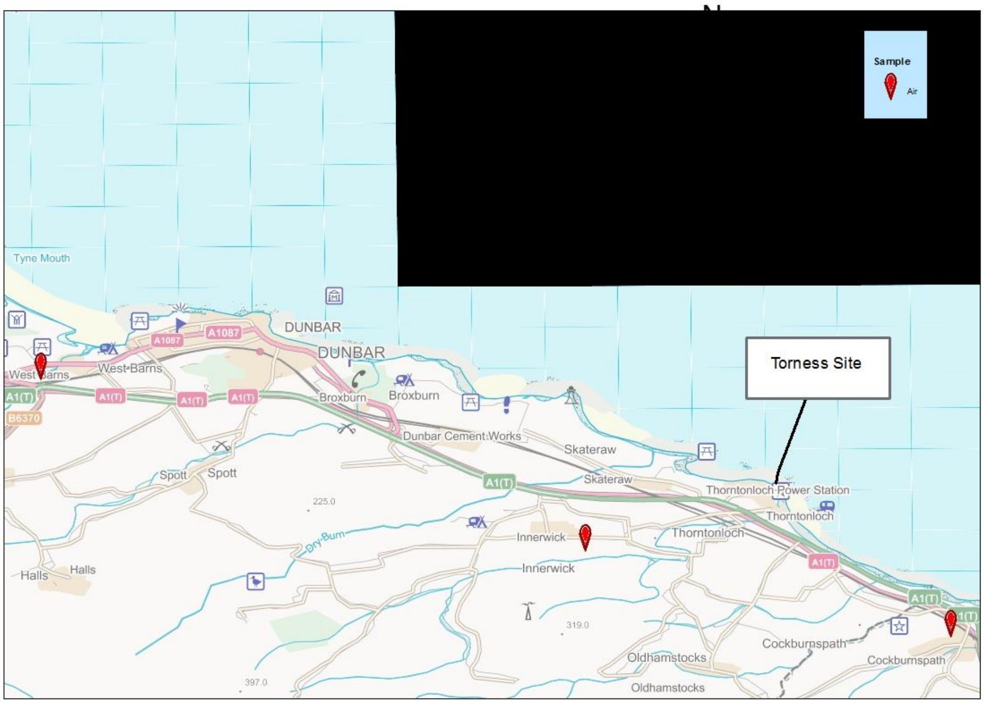

Figure 11. SEPA air sampler locations around TNPP

5.5.2 Other air sampling devices

Twenty dry cloth dust collectors in the vicinity of the TNPP are used to provide qualitative information on changes in airborne activity carried by particulate matter. These are collected monthly, and are located on and off site.

5.6 MONITORING OF TERRESTRIAL AND MARINE ENVIRONMENT

5.6.1 Introduction

SEPA's monitoring contractor, currently PHE CRCE Glasgow, has established sampling procedures for a wide range of environmental matrices, which cover all samples required by SEPA and FSS's joint environmental monitoring programme. The contractor holds ISO17025 accreditation for sampling many sample types, including surface waters, sediment, seaweed, shellfish, soil and grass.

Where samples are procured from local suppliers, the contractor ensures collection from the supplier in order to control all samples. This safeguards the integrity of the samples and that they are transported and stored in suitable conditions to prevent sample degradation.

Ten-figure sampling co-ordinates are determined by GPS. SEPA requires its contractor to provide all relevant National Grid Reference (NGR) co-ordinates.

Forms are completed at the time of sample collection and/or field measurement. These forms are designed to record all relevant information including:

- Location of sampling site (10 figure grid reference);
- Name of sampler(s);
- Prevailing weather conditions;
- Sketch diagram of sampling location (for new sites);
- Details of instruments used (serial numbers or other identification);
- Details of instrumental measurements (e.g. beta dose rates, instrumental counts and count time etc.);
- Types of samples collected;
- Contractor sample reference numbers.

These sampling forms are stored with the sample records and become part of the traceable chain of evidence from sample collection to analytical results.

SEPA's monitoring programme for radioactivity is overseen by the Environmental Radioactivity Monitoring Task Team (ERMTT) which includes representatives from SEPA, Scottish Government, Food Standards Scotland, Public Health England, and the primary contractor.

5.6.2 Surface water

SEPA's contractor obtains freshwater samples from all the collection points specified in the environmental monitoring programme which are represented in Figure 12. Most samples are collected by the contractor directly, although, due to access difficulties, some samples are supplied by Scottish Water through an established arrangement. Samples are collected in buckets taking care not to include sediment from the banks of the water body. Water is transferred to a clean carboy which is rinsed twice with the sample before final collection. Autonomous surface water samplers are not deployed currently in Scotland.

SEPA does not require details of the water flowrate to be measured at the time of sample collection. As Scotland's primary environmental regulator, SEPA has duties to manage the water resources of the country for flood forecasting or drought management. As such SEPA operates a nationwide water flow measurement network that can be used to provide information on river depth and flowrate. It is not possible to continuously monitor all rivers so SEPA can use data from primary rivers to estimate the flow/depth in adjoining rivers.

Water samples are filtered at the laboratory and acid stabilised before storing at ambient conditions. Freshwaters are analysed by gamma-ray spectroscopy, gross alpha and gross beta counting and for tritium content.

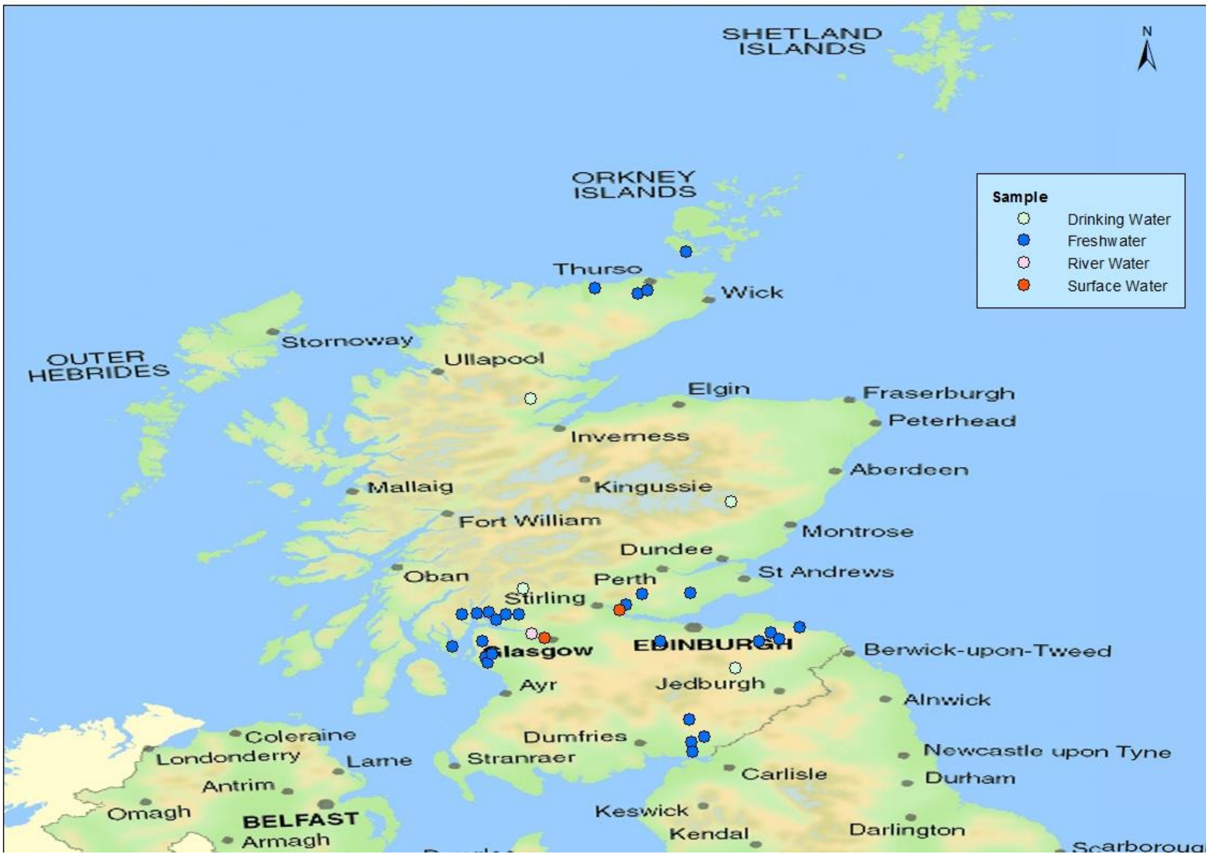

Figure 12. Locations of surface water (including drinking water) samples across Scotland

5.6.3 Ground water and drinking water

Drinking water samples are taken as part of the freshwater network as described in 5.6.1 above. Groundwater samples are taken as part of a background monitoring network and are therefore distant from all nuclear sites. Sample locations are determined by SEPA's groundwater team. They include ten locations sampled twice per year providing 20 samples per year covering summer and winter flows. Two locations remain static, whilst the remaining 8 are altered each year. Boreholes are purged prior to sampling according to defined procedures, depending on the borehole and aquifer type. Samples are transferred by the SEPA sampling team to SEPA's monitoring contractor for radionuclide analysis. Autonomous ground or drinking water samplers are not deployed currently in Scotland.

Samples in many cases are collected by the relevant Water Company that controls the site and either forwarded to, or collected by, the contractor. Water samples are filtered at the laboratory and acid stabilised before storing at ambient conditions. Groundwater samples are analysed by gamma-ray spectroscopy, gross alpha and gross beta counting and for tritium content.

5.6.4 Seawater

Seawater samples are collected up to 2 hours after the local high tide. Salinity measurements are made at time of collection to ensure the salinity of the water is greater than 20%. Seawater is collected by immersion of a clean carboy into the water body. The carboy is filled and emptied twice before collection of the sample. Typical sample volumes are 5 or 10 litres depending on the analyses required.

5.6.5 Soil

SEPA's contractor collects soil samples from the same quadrants as grass samples. The sampling locations are shown in Figure 13. Five cores are taken to form a representative sample. After removal of surface vegetation soil cores are collected with root mat to a specified depth. Five cores are collected in and 'X' pattern from within a 1 m quadrant. The core depth is determined by the specific sampling objective although 20 cm is considered routine. In total 3 – 5 kg of soil is collected.

Figure 13. Location of soil and sediment samples across Scotland

5.6.6 Sediments

Sediment samples are collected from intertidal areas to a depth of up to 2 cm at the locations shown in Figure 13. Sufficient sample is collected to allow all analyses to be completed. Sample timing is such that the sediment is not under or very close to the seawater level. Typically about 3 - 4 kg is collected, although the mass will vary depending on the analysis schedule.

5.6.7 Seaweed

SEPA's monitoring contractor has experience in the collection and identification of types of seaweed. Therefore, those species preferred by SEPA (F. Vesiculosus, F. Spiralis and F. Serratus) are collected where available. Should some other species be the only choice, the contractor identifies the species and reports this to SEPA.

The contractor collects samples from the growing tips of the plants (top 8 – 10 cm) as this is representative of recent growth. Roots/feet are not collected. Typically 8 – 10 kg of fresh plant is collected.

5.6.8 Terrestrial biota and flora

Terrestrial biota and flora samples are collected around each nuclear site.

5.7 MONITORING OF FOOD

5.7.1 Milk

SEPA's monitoring contractor currently has an existing network of farms from all locations specified in the environmental monitoring programme. The contractor operates two types of sample collection. A postal system whereby monthly samples are collected and returned from the farms using supplied sample bottles and pre-paid packaging or the contractor collects the milk directly from the farms. These monthly samples are bulked to form quarterly samples, with a portion of the original monthly samples retained should further analysis be required after the bulk sample analysis. Typically two litres of milk are collected per month.

5.7.2 Mixed diet

The contractor has established networks of suppliers for purchase of the ingredients of mixed diet samples at the locations specified by the SEPA. The heterogeneous fresh samples are blended in food processors following the ratio described in the environmental monitoring programme. The mixed sample is then freeze dried and the dry material blended a second time to ensure a high degree of sample homogeneity before further sub-sampling and analysis.

Canteen meals are currently purchased in the Queen Elizabeth University Hospital, Glasgow. These are treated in a similar way to the mixed diet samples described above. Typically 2 – 6 kg of sample is required to fulfil the analytical requirements, depending on site.

Locally grown produce is frozen on return to the laboratory before further processing. Food samples are prepared as if for consumption, with the edible portion freeze dried. These are then homogenised in a blender and stored at ambient temperatures.

5.7.3 Seafood

SEPA carries out sampling and analysis of mussels, fish, crustaceans and other shellfish. The sampling locations are represented in Figure 14.

SEPA’s monitoring contractor undertakes mussel collection to the requirements of the environmental monitoring programme, i.e. individual mussels in the size range of 40 – 60mm. Typically, 8 – 10 kg of fresh mussels are collected to reach the specified limits of detection. However, where this is not a sustainable practice, smaller samples may be collected. Where this adversely affects the analytical detection limit SEPA is informed and a compromise solution is reached balancing availability of species, sustainability of collection and analytical requirements.

Fish, crustaceans and other shellfish are purchased through an established network of local suppliers or sampled by SEPA’s contractor. The contractor has a network for the collection of fish and shellfish samples around all nuclear sites in Scotland. This network includes suppliers for all samples specified in the environmental monitoring programme. As for other seafood samples, the contractor endeavours to collect only mature specimens that would be considered large enough to eat and, where multiple specimens are required to provide sufficient sample, specimens of similar size are provided. Enough sample is purchased to give about 2 – 3 kg of edible portion.

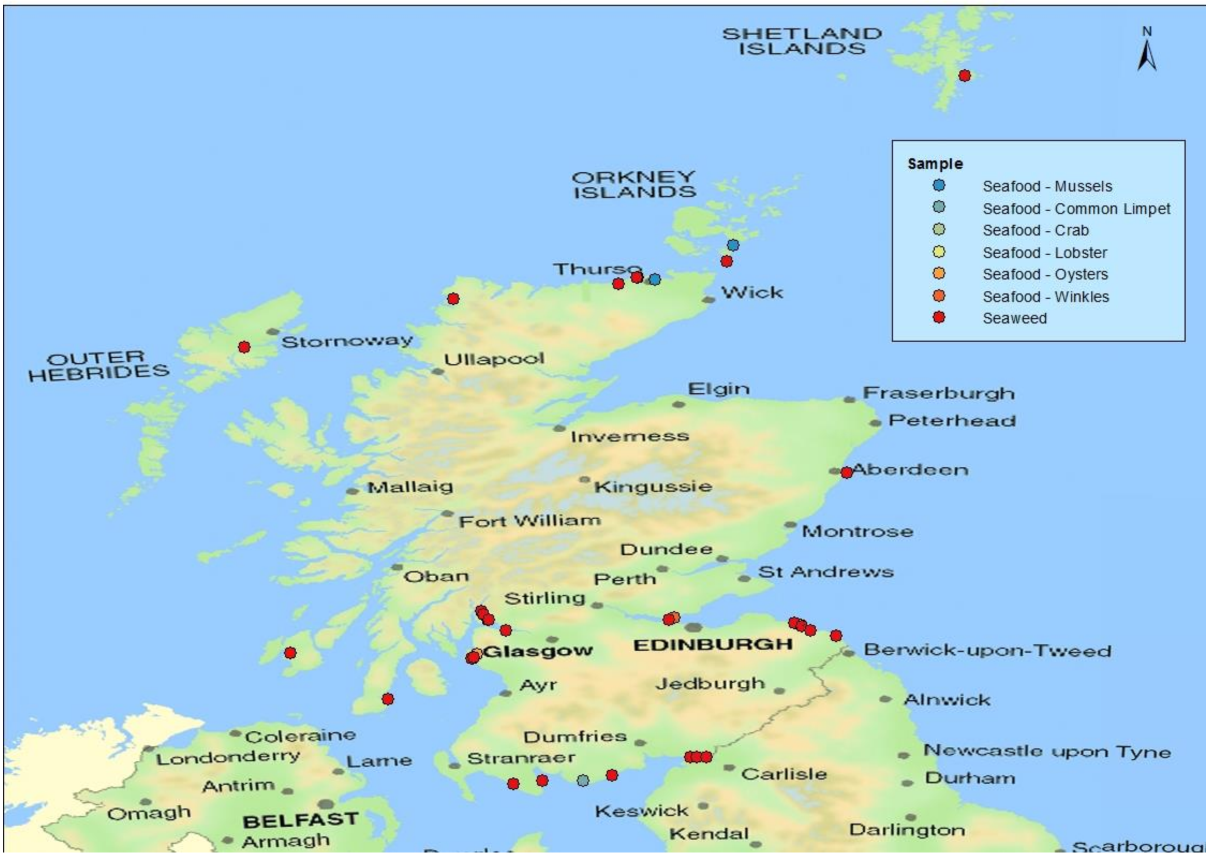

Figure 14. Location of seafood samples

5.8 OPERATOR'S MOBILE MEASUREMENT SYSTEMS

Torness NPP has several vehicles that can be deployed to take measurements both on and off site during an emergency situation. Vehicles designated Mobile 1, 2 and 3 are all vans that can go off-site. They are equipped with the following instruments:

- GMI VISA gas detector– CO_2 concentration up to 25%
- BP4/4A/Mini690 – beta castle for measuring contamination via air samples / swabs
- L50 Air sampler – For the evaluation of airborne contamination (Beta/Gamma) via Maypack (activated charcoal) or filter paper
- RADEYE – Gamma dose rate up to 100 mSv/h
- Electra/AP2 – Alpha contamination probes
- Electra /HP260 – Beta/Gamma contamination probes

Mobile 2 also has;

- Electra 44B – Electron capture contamination probe
- RO10 – Beta and gamma activity up to 10 mSv/h
- L10B portable air samplers
- Teletectors® – Gamma dose rate up to 10 Sv/h
- NM2 – Neutron dose rate

There is also Mobile 5 which is an electric vehicle for on-site surveys, it carries;

- RADEYE – Gamma dose rate up to 100 mSv/h
- L50 Air sampler – Mass of gas onto a filter paper for beta and gamma detection
- Electra/AP2 – Alpha and beta probes
- Electra HP260 - Alpha and beta probes
- Teletectors – Gamma dose rate up to 10 Sv/h

- GMI VISA – CO_2 up to 25%

Whilst these vehicles can collect samples i.e. grass, any gamma spectrometry requires the samples to be returned to the District Survey Laboratory (DSL).

5.9 SEPA MOBILE MEASUREMENT SYSTEMS

SEPA currently has a number of mobile NaI detectors (2x2" and 3x3"). The 2x2" NaI detectors have nuclide identification capability and an in built dose rate monitor. The 3x3" NaI systems are linked to a GPS unit to allow data to be plotted on a map interface.

5.10 LOCAL METEOROLOGICAL STATIONS

A map of meteorological monitoring stations across the United Kingdom is available from the UK Met Office[7] which is the United Kingdom department responsible for providing a weather monitoring network. There are multiple stations close to the Torness site. The site at Charterhall is the closest automatic station and provides data on temperature, wind direction, wind speed and gust, visibility, humidity and pressure on a regular basis. It is located at +55.709, -2.383 and sits at 112 m above mean sea level, approximately 18 miles to the south of the Torness site.

5.11 INFORMATION FOR THE GENERAL PUBLIC

The results of the monitoring programme are used to undertake dose assessments to ensure public doses do not exceed the regulatory limit. The monitoring data and the results of the dose assessments are published annually in the UK Radioactivity In Food and the Environment (RIFE) report**.**

6 LABORATORIES PARTICIPATING IN THE TORNESS ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAMME

6.1 OPERATOR'S LABORATORY FOR ENVIRONMENTAL SAMPLES

6.1.1 Introduction

The district survey laboratory (DSL) is located on-site at Torness and is geographically separate from the reactor building. Only environmental and low activity samples are analysed in the laboratory.

6.1.2 Sample reception, identification and preparation

Sample reception is detailed within the station document HPS/DS/041(W) – *Receipt and Recording of Collected Samples*. Samples received in the DSL will be allocated a unique laboratory reference code in the form TOR/{type}/YY/NN. TOR identifies the station, type identifies the sample type (as listed below), YY the year and NN a unique incrementing sequential sample number.

Sample type	Sample prefix	Sample type	Sample prefix	Sample type	Sample prefix
Apples	AP	Grass	G	Seawater	WS
Crab	CR	Lobster	LOB	Seaweed	SW
Dry cloth collectors	DCC	Milk	M	Sediments	SD
Effluent waters	EFF	Nephrops	PR	Soil	S
Fish – Demersal	DMF	Plant waters	PW	Winkles	WK
Fish – Gadoid	GDF	Potatoes	POT		

Sample preparation and measurements follow the program detailed in HPS/DS/011, which details the source of each sample, the frequency of testing, the requirement and scope of the analysis as well as the responsible persons and references to the appropriate documents.

[7] http://www.metoffice.gov.uk/public/weather

6.1.3 Sample measurement techniques

The table below presents the environmental samples handled, the measurement technique and the counting time.

Sample type	Number & Location	Isotope	Analysis type	Count time
Dry Cloth Collectors	8 on-site 12 off-site (4 each inner, outer and control zone)	^{60}Co, ^{134}Cs, ^{137}Cs (+ any other γ emitter)	γ spectrometry	60000 sec
Grass	9 off-site (3 from each zone)	^{60}Co, ^{131}I, ^{134}Cs, ^{137}C (+ any other γ emitter)	γ spectrometry	60000 sec
		^{35}S	Liquid Scintillation Counting (LSC)	100 min
Milk	1 off-site (1 from control zone)	^{60}Co, ^{131}I, ^{134}Cs, ^{137}Cs (+ any other γ emitter)	γ spectrometry	60000 sec
		^{35}S	LSC	100 min
		Total β	Berthold counter	1000 min
		^{14}C	Off-site analysis	-----
Sediment	6 off site (2 from each zone)	^{40}K, ^{60}Co, ^{54}Mn, ^{110m}Ag, ^{137}Cs (+ any other γ emitter)	γ spectrometry	60000 sec
		Total β	Berthold counter	1000 min
Seaweed	1 on-site and 6 off-site (2 from each zone)	^{40}K, ^{60}Co, ^{54}Mn, ^{110m}Ag, ^{137}Cs (+ any other γ emitter)	γ spectrometry	200000 sec
		Total β	Berthold counter	1000 min
Seawater	2 off-site (2 from Inner zone)	^{40}K, ^{60}Co, ^{54}Mn, ^{110m}Ag, ^{137}Cs (+ any other γ emitter)	γ spectrometry	60000 sec
		^{3}H	LSC	60 min
Crustaceans - Winkles	1 on-site and 6 off-site (2 from each zone)	^{60}Co, ^{54}Mn, ^{110m}Ag, ^{137}Cs (+ any other γ emitter)	γ spectrometry	60000 sec
		Total β	Berthold counter	1000 min
Crustaceans (Nephrops), Lobster, Crab	1 set of each from Thorntonloch Bay	^{60}Co, ^{54}Mn, ^{110m}Ag, ^{137}Cs (+ any other γ emitter)	γ spectrometry	60000 sec
		Total β	Berthold counter	1000 min
Fish – Gadoid and Demersal	1 set of each from Thorntonloch Bay	^{60}Co, ^{54}Mn, ^{110m}Ag, ^{137}Cs (+ any other γ emitter)	γ spectrometry	60000 sec
		Total β	Berthold counter	1000 min
Crops – Apples and Potatoes	3 off-site (1 set from each zone)	^{14}C	Off-site analysis	-----
Soils	11 off-site samples collected over 5 years	^{14}C	Off-site analysis	-----

6.1.4 Sample measurement equipment

The following table shows details of the equipment used in the lab, the calibrations and routine source checks carried out.

Equipment	Model	Calibration	Operation documents	Calibration documents
LSC	Perkin Elmer Tricarb 2900	Isotech annual service contract (call off included)	ESG/RC/010	BEG/SPEC/SHE/ENVI/034 HPS/DS/042(W)
γ spectrometer – HPGe detector	GEM30P4	Ametec annual service contract (call off included)	HPS/RC/039	BEG/SPEC/SHE/ENVI/033 HPS/DS/043(W)
	GEM30P4			
γ spectrometer – Digital Gamma-Ray Spectrometer	DSPEC+			
	DSPEC+			
γ spectrometer – Electrical cooling system	CFG-X-COOL-II-230 and CryoSecure			
γ spectrometer - UPS	SU3000 iNet			

Equipment	Model	Calibration	Operation documents	Calibration documents
Gas Proportional Counter	Berthold 10 Channel analyser - LB770	Ametec annual service contract (call off included)	HPS/DS/037	HPS/DS/035(W)
	Alpha/beta discriminator - LB2025			
	Low activity data system - LB530			
Alpha Castle	Canberra Alpha drawer and SC105 scaler	Annual service and calibration carried out in-house	HPS/RC/004(W)	EMITS
Beta Castle	Canberra beta castle and 6-90 scaler			
Furnaces (x3)	Nabertherm, LV15/11/B170 LV15/11/B180 LV15/11/B180	Hamilton Control systems service contract	As detailed in sample prep protocols	Covered under the service contract
Ovens	Binder large oven –ED720	As required	As detailed in sample prep protocols	Covered under the service contract
	Gallenkamp Hot Box oven size1			
Fume hoods	4	Service contract in place	As detailed in sample prep protocols	Covered under the service contract
Freeze Drier	Thermo ModulyoD 230	Service contract in place	As detailed in sample prep protocols	Covered under the service contract
	Edwards RV12 vacuum pump			
	Savant VLP285 vacuum pump			
General Laboratory Equipment	i.e. Pipettes, Balances, pH meters etc	As required	HPS/DS/035(W)	NA

- Liquid scintillation counting (LSC)

Daily checks include a self-normalisation/auto-calibration (SNC) which is performed using two unquenched sources and an unquenched background. Measurement of this SNC set is used to calibrate the instrument and set the zero quench point. Traceable ^{3}H and ^{14}C standards (Perkin Elmer Organic capsules) are run prior to analysis on the LSC. The results obtained (decay corrected activity and % efficiency) are recorded and only if they are within an acceptable range (+/- 10% from the certified activity) is the LSC then used for the analysis of samples. Finally a fresh deionised water background is prepared to check for active contaminants in the scintillant and deionised supply. All of the results are maintained in the lab. Quench sets are prepared as detailed in BEG/SPEC/SHE/ENVI/034 and HPS/DS/042(W); they are counted and associated with the relevant protocol; the quench correction allows maximisation of the counting efficiency for the chosen counting regions.

- Gamma spectrometry

A traceable mixed gamma source from High Technology Sources Limited (HTSL) is used to prepare a number of standards as detailed in BEG/SPEC/SHE/ENVI/033 and HPS/DS/043(W). These standards are used to calibrate the gamma specs (both energy and efficiency) as required. The standards are replaced every 18 months. A weekly check is carried out using one of the prepared standards, only if the counted activity is within 5% of the certified activity, the gamma spec can be used to count samples.

- Alpha/Beta castles

Each lab has a set of ^{241}Am and ^{36}Cl standards that are used to check the responses of the α and β castles respectively.

- Gas proportional counter

^{241}Am and ^{40}Co standards are used to check the response of each detector head (10). The α is checked before and after analysis and the β is checked weekly (when in use).

6.1.5 Data handling

Every sample that arrives at the DSL is given a unique identifier. This number is used at every stage of the analysis so each data set is unique. Initially the data is saved to the counting device. A hard copy of the data is produced and this is kept in the quarterly file to be sent to ESG along with the calculations for verification. The data is entered into the Laboratory Information Management System (LIMS) by the DSL operator and this is verified by ESG against the supplied raw data. Once verified the LIMS data is completed so that it is available to generate measurement protocols.

The paper records are maintained in ESG for several years, they are then scanned into Life time records and the folders are transferred to the archives for longer term storage. The computers in the DSL are backed up every 6 months onto a CD.

6.1.6 Reporting

For all of the reportable radionuclides where the data exceeds the MDA the data is reported as a positive result. Where the result is at or below the MDA the MDA is recorded as a positive number.

At the end of each quarter the type and number of each sample collected and analysed is checked and the quarterly report for SEPA is generated (RSA/A/0070116/VN03, Section 9.1.1, Table 9.1 section 1). The report details all of the samples collected. The results are tabled; each table has a notes section available for additional information (such as positive results for anthropogenic radionuclides). The land and beach gamma dose rates are graphed for trending. Any additional information such as ^{14}C or alpha results are captured in the appendices.

The report is generated in Business Objects which extracts the data directly from LIMS. Prior to publication it is verified and approved by an ESG engineer, the DSL technician and the ESG group head. The report has to be provided to SEPA within 90 days of the end of the month being reported. The full report is scanned and entered into life time records and the signed original is sent to SEPA.

6.1.7 Participation in inter-comparison exercises and proficiency tests

There are currently no inter-comparisons undertaken with district samples. Torness occasionally participates in the National Physical Laboratory (NPL) Environmental Radioactivity Proficiency Test Exercises (PTE's). These provide a traceable mixed low level gamma standard to the station. Once analysed the gamma spectrometry results are sent to the NPL which provides a report detailing the accuracy of the activity determination.

6.2 REGULATOR'S LABORATORY FOR ENVIRONMENTAL SAMPLES

6.2.1 Introduction

Public Health England (PHE) Centre for Radiation, Chemical and Environmental Hazards laboratory at Glasgow (CRCE Glasgow), is SEPA's current contractor for the collection and analysis of environmental and food samples around Scotland to satisfy the requirements of SEPA, FSS and Scottish Government. PHE is contracted in this capacity under a commercial arrangement to SEPA. All results and information relevant to the environmental monitoring programme are reported directly to SEPA. No information is disclosed to third parties, even within the PHE, without prior authorisation by SEPA.

No analyses are outsourced to third parties. CRCE Glasgow holds ISO 17025 accreditation.

6.2.2 Sample reception

Samples can be collected directly from the environment by PHE staff, collected by PHE staff from suppliers or sent by third parties to the PHE laboratory. Whenever PHE takes control of samples it is assigned a unique reference number. This number is used to identify the complete sample record, recording all sampling, preparation and analysis details. This system provides SEPA with a complete traceability chain from collection to reporting.

Each sample expected to be collected as part of the monitoring programme is also allocated a unique SEPA sample reference code which is used to identify the sample within the SEPA sample record system after receipt of results from PHE. Where new samples are added to the monitoring programme (e.g. following a change of supplier or introduction and a new sample matrix) a new SEPA reference code is generated and added to the sample record.

6.2.3 Sample preparation

Sample preparation techniques are selected based on the sample matrix and tests to be undertaken. In general, sample collection and preparation techniques are selected to be consistent with the advice provided in the Radiological Monitoring Technical Guidance Note 2: Environmental Radiological Monitoring, (EA/SEPA/FSA December 2010), usually referred to as TGN2.

A brief description of matrix-specific preparation techniques is given below:

- <u>Sediment</u>

Samples are collected in heavy duty plastic bags at ambient temperature for transport and refrigerated whilst waiting further processing. Samples are oven dried at 80°C (wet/dry ratio recorded), sieved (2 mm sieve), homogenised and stored at ambient temperatures.

- <u>Seawater</u>

Samples are filtered on receipt in the laboratory (0.45 micron filter). The water phase stabilised with acid (5 ml HNO_3 per litre) and stored at ambient conditions. If the analytical suite is not appropriate for acidification (e.g. ^{14}C, iodine nuclides), the sample may be split and part stabilised, part refrigerated for further analysis.

- <u>Seaweed</u>

On return to the laboratory, samples are refrigerated until further processing. Samples are then oven dried at 80°C (wet/dry ratio recorded), ground for homogenisation (heavy-duty cross-beater grinder) and stored at ambient temperatures.

- <u>Seafood</u>

Seafood samples are cooked on receipt by the laboratory. The edible portion is removed and freeze dried. The dried sample is ground, homogenised and stored at ambient temperatures.

- <u>Milk</u>

Milk samples are refrigerated on receipt in the laboratory until further processing. Bulk samples are freeze dried and the dry sample stored at ambient temperatures.

- <u>Locally grown produce</u>

Locally grown produce is frozen on return to the laboratory before further processing. Food samples are prepared as if for consumption, with the edible portion freeze dried then homogenised in a blender and stored at ambient temperatures.

- Grass

On return to the laboratory, samples will be refrigerated until further processing. Samples are then oven dried at 80°C (wet/dry ratio recorded), ground for homogenisation (heavy-duty cross-beater grinder) and stored at ambient temperatures.

- Soil

Soil samples are transported to the laboratory and kept refrigerated until processed. Samples are oven dried at 80°C (wet/dry ratio recorded), sieved (2 mm sieve), homogenised and stored at ambient temperatures.

- Freshwater, drinking water, rainwater and surface water

Water samples are filtered at the laboratory and stabilised with acid before storing at ambient conditions.

6.2.4 Measurement devices available in the laboratory

The PHE CRCE Glasgow radiometrics laboratory is fully air-conditioned. The majority of counting equipment is connected to the CRCE Glasgow LIMS (Laboratory Information Management System), allowing for automatic transfer and processing of counting data. This reduces possible data transcription errors in all analyses. The radiometrics laboratory houses the following instrumentation:

- 8 high purity germanium detectors for gamma spectrometry
    - 4 Harwell gamma spectrometry systems, operated with Genie 2000 spectral analysis software
    - 4 new high efficiency detectors (April, 2012)

Detectors are calibrated annually using mixed nuclide standard of national traceability. Weekly QC performance checks are undertaken and recorded.

- 72 chamber alpha spectrometry system

The system control and spectrum analysis is performed using the client/server version of Canberra's Alpha Apex software, with the data being stored in a Microsoft SQL Server database. The Alpha Analyst and Alpha Apex software are fully supported and maintained by Canberra.

Detectors are calibrated for energy response annually. Efficiency response is not calculated specifically but monitored for consistency through on-going QC measurements.

Results are calculated through Alpha Apex software package and uploaded into the LIMS.

- 4 liquid scintillation spectrometers
    - 3 Perkin Elmer 1440 'Quantulus' spectrometers, operated with manufacturer software
    - 1 Perkin Elmer 1414 spectrometer, operated with manufacturer software.

Detectors are calibrated annually. Weekly QC checks monitor quench, efficiency and background performance of the LSC's. Counting data is transferred to the LIMS. Calculations are undertaken inside the LIMS.

- 3 gas flow alpha/beta particle detectors
    - 1 Canberra LB4110 multi-head detector
    - 2 Tennelec 5XLB

Detectors are calibrated annually. Weekly QC checks monitor quench, efficiency and background performance of the detectors. Counting data is transferred to the LIMS. Calculations are undertaken inside the LIMS.

The chemistry service has a separate laboratory and counting room, containing:

- Inductively coupled plasma mass spectrometry (Agilent 7700x) with collision cell and auto changer

Calibrations are made using standard solutions of traceable to national standards. All chemical and radiochemical instrumentation is supported by preventative maintenance contracts which guarantee annual inspection, regular upgrades and rapid response to technical problems. Freeze driers are subject to annual preventive maintenance. Balances are inspected annually during their calibration.

6.2.5 Sample measurements

All preparation and analytical procedures are detailed within the CRCE Glasgow Technical Manual. This is controlled within the laboratory's ISO 17025 accreditation quality system. Method statements for sample analysis procedures for all analytes as specified in the environmental monitoring programme are presented in Annex 4 to this report.

6.2.6 Measurement results recording and archiving

Where sample measurement results are recorded though paper-based systems, the sample record is identified by a unique laboratory sample number (which also corresponds to a unique SEPA sample code, provided by SEPA). All analytical data is independently checked and signed to verify measurement results. Sample records are archived within CRCE Glasgow. Records are retained for six years.

Results are reported for all radionuclides listed in the environmental monitoring programme, including those nuclides which fall below the limit of detection. In the latter case, results are reported as below the contract detection limit or laboratory detection limit, whichever is higher.

The detection limit for a counting technique is calculated following the method of T. Summerling and S. Darby (National Radiological Protection Board Report NRPB-R113, 1981). In this approach, a Critical Level, L_C, is defined as the level at which there is a 95% confidence level that there is activity statistically significant above background. The Detection Level, L_D, is then defined as the value at which there is a 95% confidence that the observed count rate is statistically greater than L_C. Under most counting conditions, $L_D \cong 3.3\sigma_B$, where σ_B is the standard deviation on the background count rate.

It has been demonstrated that this approach is consistent with the methodology described in ISO 11929 2010 '*The determination of the detection limit and decision threshold for ionizing radiation measurements*'.

Where spectral analysis is performed by manufacturer-provided software (e.g. for gamma-ray spectrometry), detection limits are calculated according to the settings in the manufacturers software.

6.2.7 Data handling and reporting

In 2016, the laboratory transferred record keeping from a paper-record based system to a Laboratory Information Management System (STARLIMS). This system provides secure data recording and transfer, including:

- Sample receipt and sample meta-data recording
- Full traceability on sample processing data
- Data capture from laboratory detection equipment and automated calculations
- Automatic report generation

The laboratory uses in-house database systems (operating on MS Access) for recording and charting QC data from in-house reference materials and method blanks.

6.2.8 Statutory accounting and reporting obligations

Routine environmental samples are not subject to statutory accounting. If such accounting is needed a formal sample is taken which has a full audit trial.

Reporting obligations on SEPA's contractor are that data are provided in a form which can be loaded onto a SEPA database for analysis. This database was developed following the March 1999 European Commission Article 35 verification in Dounreay[8]. This Oracle based database is used to collate and extract data for compliance with Article 36 of the Euratom treaty and other national and international obligations.

6.2.9 Sample storage

Samples are stored from six months from date of report under suitable conditions to prevent degeneration of the sample.

6.2.10 Quality assurance and control procedures

Glasgow Radiochemistry Services Laboratories is accredited to ISO 17025 (Laboratory number 1502). Accreditation to this standard ensures the quality of data generated within this project. In addition to ISO 17025 accreditation at CRCE Glasgow operates a registered ISO 14001 environmental management system.

All accredited analytical methods have been suitably validated. Validation data are constantly reviewed by United Kingdom national accreditation body, UKAS, as part of the annual surveillance visit. These are organised such that the full schedule of accreditation is subject to UKAS review over a quadrennial cycle.

Both original method validation and on-going demonstration of performance are provided through the analyses of a number of types of material, namely:

- Certified Reference Materials (CRM);
- In-House Reference Materials (IHRM);
- Spiked samples; and,
- Intercomparison exercises.

PHE carries out internal QA audits under its ISO 17025 accreditation as well as audits against ISO 14001.

Procedures are in place for auditing the QA management system such that all aspects of the system are audited annually. There is an annual Senior Management review which allows the Director to satisfy him/herself that the QA system is being implemented fully.

The laboratory undergoes regular audits as part of PHE's commitment to QA performance:

- External audit by UKAS assessors to maintain ISO 17025 accreditation. Comments from UKAS surveillance visits have been very positive with no major conformities received in over 10 years.
- The laboratory runs a comprehensive programme of internal audit designed to cover the entire QA system annually. This programme is reviewed annually by UKAS assessors.
- There are procedures in place for identifying non-conforming work or potential QA issues. Where identified, these will lead to full audit and resultant preventive or corrective actions taken.

6.2.11 Participation in inter-comparison exercises and proficiency tests

CRCE Glasgow participates regularly in national and international interlaboratory comparisons, including regular participation in NPL (National Physics Laboratory Environmental Radioactivity Proficiency Test), MAPEP (*Mixed Analyte Performance Evaluation Program*, US DoE), IAEA, Procorad and QMEQAS (*Quebec Multielement External Quality Assessment Scheme*) schemes.

[8] https://ec.europa.eu/energy/sites/ener/files/documents/tech_report_dounreay.pdf

Exercises are selected on the basis of relevance, both in terms of analytes and matrices. In the last five years, CRCE Glasgow has participated in a series of exercises as presented in Annex 5 to this report.

7 TORNESS NPP LIQUID AND GASEOUS RADIOACTIVE DISCHARGE MONITORING

7.1 INTRODUCTION

The two reactor units in the TNPP discharge gaseous radioactive material to the atmosphere via ventilation stacks and liquid radioactive material to the sea via a common coolant discharge channel. Since Torness reactors are gas-cooled, the potential for significant liquid releases is small, but there is a continuous outflow of short-lived gaseous radioactive material.

Discharges are monitored by sampling and continuous on-line methods to ensure compliance with the statutory discharge limits and regular discharge reports are prepared for the authorities.

7.2 DISCHARGE LIMITS

Discharges of liquid and gaseous radioactive wastes from TNPP are carried out in accordance with limits and conditions set in the Authorisation (reference RSA/A/0070116) granted by SEPA under section 13 of the Radioactive Substances Act 1993 (RSA93). The certificate was originally granted in June 2007 and has been subsequently varied three times. The most recent variation (number VN03) was granted in May 2016 and consolidates all previous variations. It specifies numerical limits for liquid and gaseous discharges as shown below.

Liquid discharge limits

Radionuclide or Group of Radionuclides	Annual Limit (GBq)	Quarterly Notification Level (GBq)
Tritium	700,000	175,000
Sulphur-35	3,000	750
Cobalt-60	10	2.5
Alpha emitting radionuclides	0.5	0.125
Any non-alpha emitting radionuclides taken together excluding those listed individually in this schedule	150	37.5

Gaseous discharge limits

Radionuclide or Group of Radionuclides	Annual Limit (GBq)	Weekly Advisory Level (GBq)	Quarterly Notification Level (GBq)
Tritium	11,000	1,100	2,750
Carbon-14	4,500	450	1,125
Sulphur-35	300	30	75
Argon-41	75,000	Not specified	18,750
Iodine-131	2	Not specified	0.5
Beta emitting radionuclides associated with particulate matter	0.4	Not specified	0.1

These limits were set in 2007 by SEPA having regard to the operational requirements of the station, previous discharges and government policy of the time. In establishing limits of this kind SEPA is required by the Scottish Government Radioactive Substances (Basic Safety Standards) Direction 2000 to ensure that the dose limits for members of the public set out in Article 13 of Council Directive 96/29/EURATOM will not be exceeded.

SEPA has established weekly advisory discharge limits in recognition that activity released over a short timescale can potentially result in higher doses than for the same discharge over a longer timescale. In setting these weekly thresholds SEPA received advice from the Food Standards Agency that weekly thresholds should be set at either the activity that could lead to a dose of 0.02 mSv, or at 10% of the requested annual limit, whichever was higher for gaseous discharges of ^{3}H, ^{14}C and ^{35}S.

Quarterly Notification Levels (QNL's) were specified to signal circumstances where liquid or gaseous discharges were significantly above usual levels. They were set above the levels of discharge for planned events but below the level for unplanned but foreseeable events, such as small boiler tube leaks.

The Radioactive Substances Direction 2000 (Basic Safety Standards) requires that the contribution to public dose arising from authorised radioactive discharges are kept as low as reasonably achievable, economic and social factors being taken into account. This is achieved by conditions within the authorisation, which require the holder to continually seek ways to minimise discharges and their impact using best practical means. The main conditions are given below:

- The Authorisation Holder shall use the best practicable means to minimise the volume of and the total radioactivity in radioactive waste produced.
- For each of the relevant waste types and disposal routes the Authorisation Holder shall use the best practicable means to minimise the radioactivity of gaseous and liquid radioactive waste disposed of by discharge to the environment and 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.

In 2015, the authorised discharge limits specified for TNPP were reviewed by SEPA and EA along with the other EDF stations in the UK[9]. The review concluded that the existing authorised limits continue to be suitable and ensure that the environment is protected.

7.3 MONITORING OF GASEOUS RELEASES

7.3.1 Introduction

Torness NPP discharges gaseous effluents to the atmosphere from several elevated release points. CO_2 blown down (BD) from each reactor is discharged from its own stack at a height of 77 m (Figure 15 below). Annex 2 to this report presents the gaseous exhaust system details. The main radioactive discharge takes place through the two exhaust stacks.

Active gaseous effluents comprise either ventilation air from contaminated areas or discharge of reactor coolant from main and auxiliary blow down systems. Potentially contaminated heating and ventilation (H&V) extract is discharged to atmosphere through particulate filters and primary circuit coolant discharges are made via particulate and iodine adsorption filters.

Samples are collected from 13 "Contaminated Ventilation Air Discharge Stacks" -stations. Nine of these are operated continuously; two are only in service during an outage and the remaining two are used only during a blow down. Each stack has a sampling cubicle with a Maypack, bubbler bottles and a filter paper holder; the samples are analysed in the plant radiochemistry laboratory (RCL). The table below details the gaseous sampling locations. The contaminated ventilation discharge stacks are sampled three times per week, the reactor gas twice per week. The GAM systems sample continuously.

9 The details are contained in the report "A review of radioactive waste discharge limits at EDF Energy nuclear power stations", joint report by the Environment Agency and SEPA, 18 December 2015.

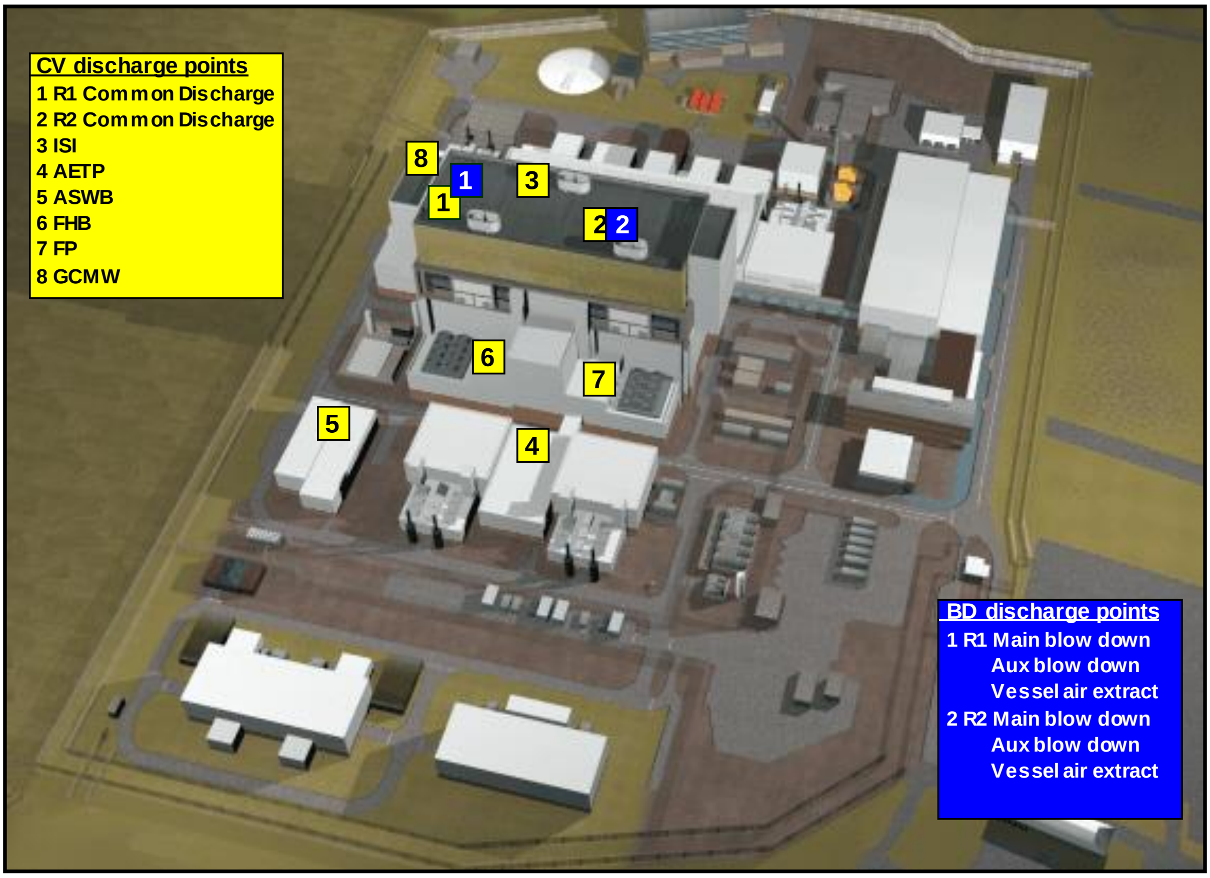

Figure 15. TNPP discharge points for airborne radioactive effluents

Gaseous sampling locations

Contaminated Ventilation Air Discharge Stacks		Reactor Gas Sampling Systems
AXBD	Auxiliary CO_2 blow down contaminated ventilation system, 52m level	R1 “A” Boiler Outlet, -4.5m level
R1CD	Reactor 1 common discharge contaminated ventilation system, 52m level	R1 “B” Boiler Outlet, -4.5m level
R2CD	Reactor 2 common discharge contaminated ventilation system, 52m level	R2 “A” Boiler Outlet, -4.5m level
FP	Fuel pond contaminated ventilation system, 32m level	R2 “B” Boiler Outlet, -4.5m level
ISI	In Service Inspection and fuelling machine maintenance workshop contamination ventilation systems, 52m level	Reactor 1 and 2 Radiochemistry Laboratory Rig, 12.5m level
FHB	Fuel handling building contaminated ventilation system, 37.4m level	R1 Gaseous Activity Monitoring System (R1 GAM)
GCMW	Gas circulator maintenance workshop contaminated ventilation system, 17.25m level	R2 Gaseous Activity Monitoring System (R2 GAM)
ASWB	Active Solid Waste Building contaminated ventilation system, 5.5m level	R1 BD – R1 blow down cubicle, 32m level
AETP	Active Effluent Treatment Plant contaminated ventilation system, 10.5m level	R2 BD – R2 blow down cubicle, 32m level
R1VAAE	R1 vessel access air extract system contaminated ventilation system, 52m level, Outage use.	-----
R2VAAE	R2 vessel access air extract system contaminated ventilation system, 52m level, Outage use.	-----

Gaseous sampling regime

Sample	Frequency	Radionuclide	Analysis type
CV Bubbler sample	3 times/week	^{3}H, ^{35}S	LSC
CV Maypack	3 times/week	^{131}I	Gamma spectrometry
CV Filter paper	3 times/week	Beta particulate	Filter paper to Beta castle
CV Filter paper monthly	all filter papers for the month	Various gamma emitters	Gamma Spectrometry
Reactor RIGS	twice a week	^{3}H, ^{14}C, ^{35}S.	LSC
Reactor Boiler Outlet	twice a week	^{131}I Beta particulate	Gamma Spectrometry Filter paper to Beta castle
GAM	continuous	Various gamma emitters (^{41}Ar, ^{133}Xe)	Gamma spectrometry

7.3.2 Contaminated ventilation systems

The contaminated discharge stacks (exhaust stacks) receive filtered air and gaseous effluent from the extract fans of the associated heating and ventilation systems. Each stack has a dedicated sampling cubicle where all of the feeds into the common discharge stack have a dedicated set of high efficiency particulate absolute (HEPA) filter banks. The flow rate in each stack is measured annually and compared to the design flow.

7.3.3 Reactor blow down systems

Each reactor is served by a separate blow down system which can release coolant gases to atmosphere. The discharge is routed via the reactor by-pass gas plant to minimise the discharge of radioactive iodine and particulate activity to the environment. This system also provides recirculation for iodine removal from the primary coolant for return to the reactor. The use of both, the blow down system and the iodine recirculation system, is a manual operation requiring opening or closing of the appropriate valves.

Each reactor gas blow down system comprises:

- two identical iodine absorber and particulate filter trains with associated pipe work and valves
- valved branch lines and gauges for measurement of gas flow, temperature and pressure, with alarms for high temperature and differential pressure
- valved branch lines with quick release self-sealing couplings and screwed end caps for gas sampling and injection points
- valved branch lines with quick release self-sealing couplings for air and carbon dioxide purge connections
- probes for sampling the quantities of radioactive iodine and particulate released during discharge of gases to atmosphere; and
- a discharge stack for each reactor, discharging to atmosphere at a high level.

7.3.4 Vessel active air extract systems

There is one vessel active air extract system (VAAES) for each reactor. Each system comprises:

- two 100 % suction pumps
- one 100 % high efficiency particulate absolute (HEPA) filter unit
- two 50 % iodine adsorption units; and
- one set of ducting, pipe work, valves, controls and instrumentation.

The control panel for the system local equipment housing (LEH 1256) is located in the control room adjacent to the pump room, and all major items of plant are located at the 10.5m level in each reactor services annexe.

7.3.5 Monitoring equipment

Sampling cubicles

Reactor gas (both R1 and R2) is sampled via cubicles and rigs which allow the gas to be run through a bubbler and a Maypack (an activated charcoal filled canister). Samples are collected and taken to the radiochemistry lab (RCL) for analysis.

The contaminated vent sampling system is contained in a steel cubicle alongside the ducting being sampled. The sampling nozzle has been set up to allow an isokinetic sample to be collected. The sample is pumped from the nozzle onto a particulate filter behind the probe and then into the cubicle. Once in the cubicle the stream splits, part passes through a bed of activated charcoal (Maypack) to collect iodine, the remainder passes through the sulphur/tritium furnace and then into the demineralised water bubbler bottles. Valves control the flow and redundancy across the pumps to allow continuous running; the control panel displays the furnace temperature, flow rates and accumulated mass flow of gas sampled.

The VAAES and the blow down cubicles operate on the same principle as detailed above but sample filtered reactor gas prior to a discharge. The VAAES is used as required, the blow down results are analysed in the RCL but they are used for reassurance, as the discharge activity is calculated from the reactor gas activity and the volume of gas blown down. This is also the case for the VAAES; the recorded outage blow down activity is calculated from the initial volume of the discharge and the activity of the gas at that time.

Sampling of the reactor gas is carried out at 2 locations:

- 0 m level — Boiler outlet cubicles (Maypack for ^{131}I analysis and particulate filters).
- 12.5 m level — RCL portable RIGS (a system which pumps reactor gas through, a furnace and a set of bubbler bottles) for sulphur/tritium analysis.

Gaseous Activity Monitors (GAM)

Reactor gas on-line monitoring is carried out to monitor for failed fuel using the Gaseous Activity Monitoring systems (GAM), which consists of an n-type germanium gamma spec detector and a stainless steel re-entrant gas chamber (one litre, Marinelli beaker). This provides continual readings for ^{133}Xe and ^{41}Ar; these activities are used as an indicator for fuel failures. The ^{41}Ar data is included in the discharge reports.

The GAM system collects coolant gas from the four quadrants of each reactor via instrument penetrations, fed to the multi-input gas selector unit. Only one quadrant gas sample at a time is selected for analysis, under control of the GAM computer. Gas is fed to the reactor gas cubicle which controls the flow rate of gas using pump assistance when the reactor is shut down. The controlled flow of gas is fed into a Marinelli beaker where a high purity germanium detector counts gamma-rays emitted from the gas. The output of the detector is processed by electronic interface modules to provide signals to the GAM computer system. There are logging facilities both locally in the GAM computer room and station wide via the local area network. In addition, an analogue display of ^{133}Xe is provided and alarms are generated to indicate high activity levels for ^{133}Xe and ^{41}Ar together with equipment fault alarms.

The maintenance and calibration of the GAMs is controlled by the station Maintenance Interval Test Schedule (MITS). Failure of the GAMs initiates bottle sampling and gamma spec analysis of the reactor gas. The gamma spec detector is covered by a service contract with Canberra and it is efficiency calibrated by NSG using a mixed gamma Marinelli source.

7.4 MONITORING OF LIQUID RELEASES

7.4.1 Introduction

The liquid releases from the Torness NPP consist of Final Delay Tank (FDT) and Tritiated Effluent Tank (TET) discharges. Active effluent arising in all parts of the station is collected locally and transferred to the active effluent treatment plant (AETP). This plant is provided to treat and store effluents in preparation for safe disposal from site. The main sources of active liquids and slurries are the active laundry, pond water treatment plant and decontamination centres including active workshops. All collection and storage tanks are provided with secondary containment to prevent leakage to the environment.

There are two discharge streams for liquid effluent within the AETP, the TET which only handles the Tritiated effluent from the gas drying process in the Reactor Bypass Gas Plant (BPGP) and FDT which receives all other treated effluents from the AETP. Once in the AETP each stream of effluent is segregated and treated in batches. The treatment options vary but include filtration, settlement, deionisation, chemical dosing or any combination of these methods. Each stream has a default pathway through the plant; this route can be altered but only with qualified advice. The treated effluent is then transferred to the Final Delay Tank where it is collected, sampled and analysed. Only when the discharge specifications are met it is discharged out into the sea via the main cooling water outlet culvert.

Typically there are 2-3 TET and 2-5 FDT discharges carried out over a month. The duration of a discharge varies depending on the overall volume but generally take between 2 and 3 hours; the actual discharge time depends on the tides. Prior to discharge the tanks are re-circulated and sampled. Sampling points for both TET and FDT are on the recirculation pipework outside the secondary containment cells. They each have a drain line and demineralised water supply for flushing. For FDT the analysis result is used to authorise the discharge. At the end of a calendar month a proportional composite is prepared and analysed by ESG; this data is used to prepare the monthly discharge results. The FDT lines have proportional sampling which collects a discharge sample that is available for 24 hours post-discharge in case there is a need to reanalyse. The TET samples are analysed and the data used for both the discharge approval and the monthly discharge activity report. For inter-comparison testing a quarterly proportional composite of the FDT samples is prepared, this is then divided and sent to National Nuclear Laboratories (NNL) for EDF and to Public Health England (PHE) for SEPA. The remaining sample is tested in-house. The same process is followed for the TET samples, with PHE receiving two quarterly samples (usually Q1 and Q2), as detailed in the table below. On average there are two TET samples and approximately 3-5 FDT samples per month.

Liquid sampling regime

Sample	Department, frequency, forms to be used	Radionuclide	Analysis
FDT Pre discharge sample	Operations recirculate and sample prior to discharge. Form HPS/A/006/1	^{3}H, ^{35}S and 'Other beta emitter'	LSC
		Alpha emitters	Filter paper (alpha castle)
		^{60}Co and ^{137}Cs	γ spectrometry
		Turbidity	Turbidity meter
FDT Monthly discharge	ESG-RCL. Monthly composite. Form HPS/RC/003/1	^{3}H, ^{35}S and 'Other beta emitter'	LSC
		Alpha emitters	Planchet (alpha castle)

Sample	Department, frequency, forms to be used	Radionuclide	Analysis
return	Form HPS/RC/006/2	^{60}Co, ^{54}Mn, ^{51}Cr, ^{134}Cs and ^{137}Cs (other gamma)	γ spectrometry
		Oil and/or Particulate	Visual
FDT Inter comparison	ESG-RCL, NNL and PHE. Quarterly proportional composite sample. Report sent to PHE and Generation Environment Management (GEM).	^{3}H, ^{35}S and 'Other beta emitter'	LSC
		Alpha emitter	Planchet (alpha castle)
		^{60}Co, ^{54}Mn, ^{51}Cr, ^{134}Cs and ^{137}Cs (other gamma)	γ spectrometry
TET Pre-discharge sample	Operations collect the sample. ESG-RCL analyse. Form HPS/RC/003/1 Form HPS/RC/006/2	^{3}H, ^{35}S and 'Other Beta emitter' (excluding ^{3}H)	LSC
		Alpha emitter	Planchet (alpha castle)
		^{60}Co, ^{54}Mn, ^{51}Cr, ^{134}Cs and ^{137}Cs (other gamma emitter)	γ spectrometry
TET Inter comparison	ESG-RCL, NNL and PHE. Quarterly proportional composite sample. Two samples a year. Report sent to PHE and GEM.	^{3}H, ^{35}S and high energy beta emitter	LSC

The discharges are pumped to the sea via a system of discharge lines presented in figure 16 overleaf. The discharge lines are double-contained, equipped with leak detection systems and installed in a concrete trench with collection sumps to avoid any possible leakage.

Before entering the cooling water culvert the FDT and TET lines are merged; each line is protected with non-return valve to ensure that there is no back flow. The discharge line expels at the bottom of the surge shaft to ensure reduced exposure and maximal mixing. The cooling water enters the surge shaft at the rate of 11.5 m^3/s (23 m^3/s with 2 pumps) - this ensures that both the TET discharge (approximately 10 m^3 over one to two hours) and an FDT discharge (approximately 70 m^3 over two to three hours) are suitably diluted before being discharged to sea.

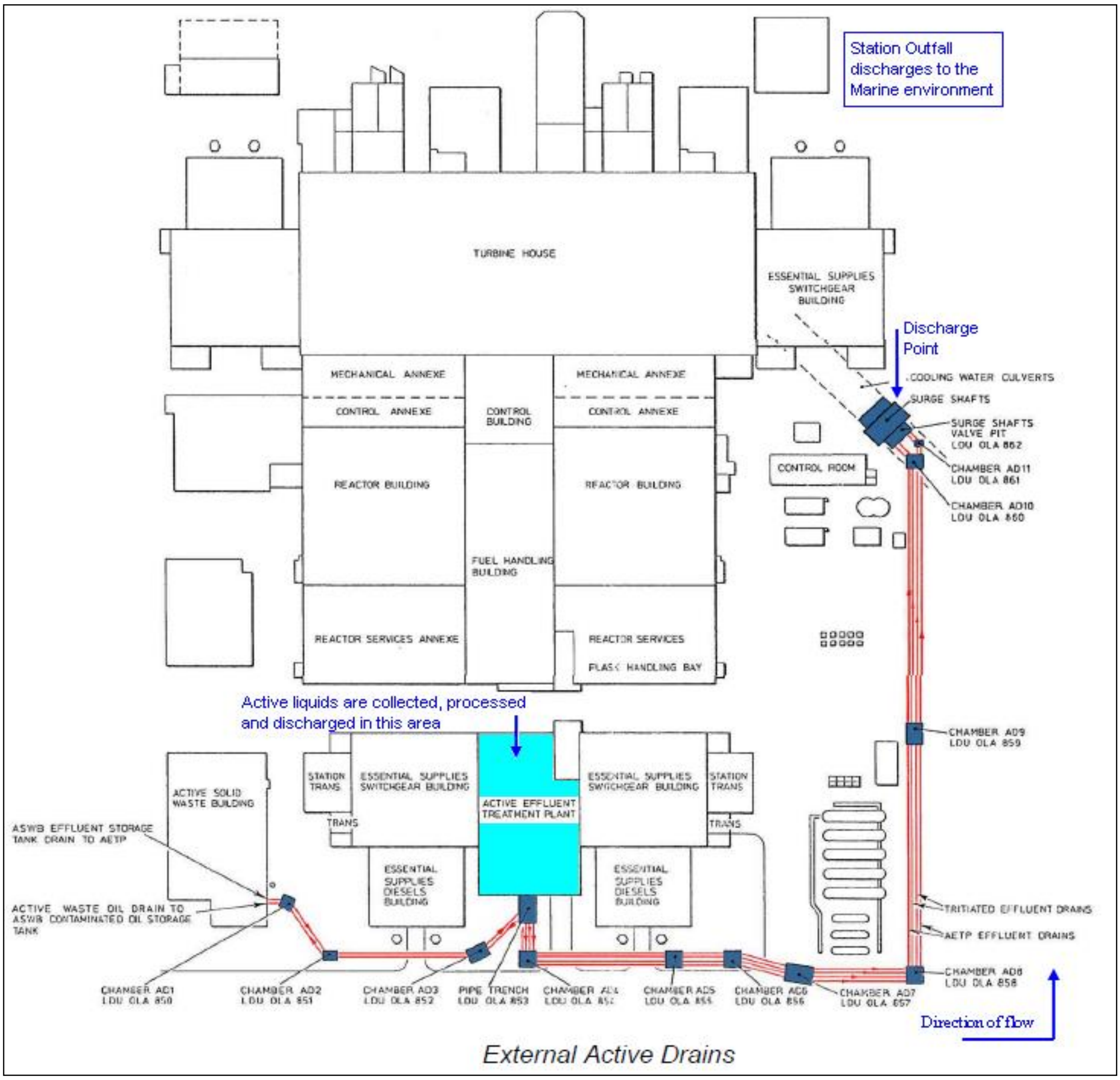

Figure 16. TNPP discharge lines for liquid radioactive effluents

7.4.2 Final delay tank discharges

The final delay tank is the collection tank for all liquid discharges other than tritiated effluent. The tank discharge system has two pumps (one duty, one standby) that draw effluent from the tanks, and a recycle line is fitted from the pumps to each tank. A sample line is taken from the recycle line downstream of an inline mixer. A flow instrument gives indication in both the Local Equipment Housing (LEH) and in the control room mimic display.

There are three concrete FDT tanks lined with epoxy resin, approximately 75, 80 and 85 m^3 volume. The effluent is filtered and biocide dosed prior to entry into the FDT. The effluents can be reprocessed through the AETP if any of the discharge conditions are not met. FDT discharges are also discharged out to the cooling water culvert. Before each discharge a sample is taken from the tank. From the results of the sample analysis the decision is taken on whether to discharge the effluent to the sea or return the effluent for further processing. Once the statutory discharge requirements have been confirmed as being met the effluent is pumped to the cooling water culverts and to the sea via the active drains sea discharge lines. Flow instruments are mounted in the pump discharge pipes. A proportional sampling system is incorporated into each of the culvert lines and has to be functional for a discharge to proceed.

The final delay tanks incorporate a double isolation system, comprising interlocking manual valves. The purpose of this system is to provide additional protection against inadvertent discharges. Prior to tank recirculation and sampling, the selected tank is quarantined, preventing further inflows to that tank, until it has been sampled, assessed, authorised for discharge and discharged. The discharge system has key switches to ensure that the valves are correctly aligned, prior to each discharge.

7.4.3 Tritiated effluent tank discharges

There are two cylindrical 15 m^3 stainless steel TET tanks (one duty and one standby). The tanks are contained with a concrete cell located within the AETP. The content of these tanks are not processed within the AETP - they are discharged into the cooling water culvert for dilution prior to discharge at the outfall.

The Tritiated Effluent Tank system has two pumps (one duty, one standby) that draw effluent from the tritiated effluent tanks. A recycle line is routed from the pumps to both tanks. The common recycle line is fitted with a sampling system. The tanks are recirculated for two hours prior to sampling to ensure sample representativeness.

The tritiated effluent tanks incorporate a double isolation system, comprising interlocking manual valves. The purpose of this system is to provide additional protection against inadvertent discharges. Prior to tank recirculation and sampling, the selected tank is quarantined, preventing further inflows to that tank, until it has been sampled, assessed, authorised for discharge and discharged. The discharge system has key switches to ensure that the valves are correctly aligned, prior to each discharge.

The tritiated effluent pumps discharge to the station cooling water culverts. A flow meter is fitted to each discharge line and gives indication in the LEH and the control room mimic display.

7.4.4 Monitoring equipment

A proportional sampling system (Aquamatic AquaCell S2) is incorporated into each of the Final Delay Tank discharge lines. During a discharge a continuous flow is delivered to one of two sampling point tundishes, located within the proportional sampler. The sampler then collects a small portion from the tundish and collects them as a bulk sample over the entire discharge period (providing a representative sample). This is then available for analysis on completion of the discharge process; it is held for 24 hours and if not collected it is returned to the FDT. Plant Item Operating Instruction (PIOI) 91500/Z156 gives instructions for taking a sample from the proportional sampler. The proportional sampler is triggered automatically when the final delay tank discharges to the cooling water outfall; the discharge will stop if the sampling system becomes unavailable. The PIOI for FDT discharges requires that the operability of the system is checked prior to initiating a discharge.

7.4.5 Regulator's liquid discharge monitoring programme

SEPA’s discharge monitoring programme is a check programme which consists of a number of samples taken for inter-comparison testing. EDF prepares a quarterly proportional composite of the FDT samples which is divided in three subsamples. One of the samples is sent to the Public Health England who analyse it on behalf of SEPA. The other parts are analysed at the station and by the National Nuclear Laboratories (NNL) on EDF’s behalf. This allows comparison of three sets of results. A similar arrangement exists with the TET samples although the PHE receive two quarterly samples (usually Q1 and Q2).

As effluent samples have a higher concentration of radionuclides than environmental samples, these samples are less prone to have activities at Detection Limit (DL) levels. The DLs for these samples are presented in the table overleaf.

Detection limits for the regulator liquid effluent monitoring

Analysis	Detection limit(Bq/l)
^{3}H	5
^{35}S	5
^{90}Sr	20
^{241}Am	0.2
Plutonium radionuclides	0.2
Total Beta	20
Total Alpha	2
Gamma spectrometry. The following radionuclides are to be routinely reported: ^{60}Co, ^{95}Zr, ^{95}Nb, ^{103}Ru, ^{106}Ru, ^{110m}Ag, ^{134}Cs, ^{137}Cs, ^{144}Ce. Other nuclides need only be reported if positive measurements are obtained.	5

8 LABORATORIES PARTICIPATING IN THE TORNESS NPP DISCHARGE RADIOACTIVITY MONITORING PROGRAMME

8.1 TNPP LABORATORIES FOR DISCHARGE SAMPLES

There are two labs within the Radiological Controlled Area that process pre-discharge samples, the base room at the entrance to the RCA on the 4.5m level and the radiochemistry lab (RCL) at the 12.5m level.

8.1.1 Sample reception and measurements

The table below presents an overview of the sample measurements in the plant laboratory. Sample documents detail the source of each sample, the frequency of testing, the requirement and scope of the analysis as well as the responsible persons and references to the appropriate documentation.

TNPP laboratory measurements

Sample	Lab	Radionuclide	Analysis type	Count time
FDT Pre discharge sample	Base room, analysis carried out by Ops. RCL only if there are problems.	^{3}H, ^{35}S and 'Other beta emitter'	LSC	20 min
		Alpha emitter	Filter paper (alpha castle)	300 sec
		^{60}Co and ^{137}Cs	Gamma spectrometry	3600 sec
		Turbidity	Turbidity meter	NA
FDT Monthly composite for discharge return (and quarterly for inter comparison)	Above sample sent to RCL for storage and monthly testing.	^{3}H, ^{35}S and 'Other beta emitter'	LSC	^{3}H (30 min) ^{35}S/OB (60 min)
		Alpha emitter	Planchet (alpha castle)	2x 60000 sec
		^{60}Co, ^{54}Mn, ^{51}Cr, ^{134}Cs and ^{137}Cs (other gamma emitter)	Gamma spectrometry	60000 sec
		Oil and/or particulate	Visual	NA

Continued overleaf

Sample	Lab	Radionuclide	Analysis type	Count time
TET Pre-discharge sample	RCL	^{3}H, ^{35}S and 'Other beta' (excluding ^{3}H)	LSC	60 min
		Alpha	Planchet (alpha castle)	2x 60000 sec
		^{60}Co, ^{54}Mn, ^{51}Cr, ^{134}Cs and ^{137}Cs (other gamma emitter)	Gamma spectrometry	60000 sec
TET Quarterly composite for inter comparison	RCL	^{3}H, ^{35}S +High energy beta emitter	LSC	60 min
CV Bubbler sample	RCL	^{3}H and ^{35}S	LSC	20 min
CV Maypack	RCL	^{131}I	Gamma spectrometry	1800 sec
CV Filter paper	RCL	Beta particulate	Filter paper (beta castle)	60 sec
CV Monthly filter paper for bulk analysis	RCL	Various gamma emitters	Gamma spectrometry	10000 sec
Reactor Rigs	RCL	^{3}H, ^{14}C and ^{35}S	LSC	^{3}H, ^{35}S (20 min) ^{14}C (15 min)
Reactor Boiler Outlet	RCL	^{131}I	Gamma spectrometry	1800 sec
		Beta particulate	Filter paper (beta castle)	60 sec

8.1.2 Measurement devices available in the laboratory

The laboratory has analytical devices for liquid scintillation counting, alpha/beta counting and gamma spectroscopy. Annex 3 presents a full list of analytical equipment.

8.1.3 Data handling

- Liquid discharges (FDT and TET)

At the pre-discharge analysis the data is initially saved to the counting device using sequential numbers so each data set is unique. The results are also generated in a print out. If the data are below the detailed limits for each radionuclide then the discharge is allowed. The raw data are then sent to ESG for entry into the Liquid worksheet, which is saved onto a secure network that is backed up regularly. The completed discharge form is kept in lifetime records with copies going to the Central Control Room (CCR) and ESG. The paper records are maintained in ESG for several years, they are then transferred to the archives for longer term storage. The computers in the RCA are backed up annually onto a CD.

At the monthly analysis, the data are initially saved onto the counters; the raw data are then retrieved and manually transferred onto the LIMS. The data entered into LIMS is then verified against both the raw data and the results obtained from the spreadsheet. Once verified the LIMS data is completed so that it is available for Business Objects to generate discharge reports.

- TET discharges

At the pre-discharge analysis, as above, the data is initially saved to the counting device using sequential numbers so each data set is unique. The results are also generated in a print out. The calculated data is transferred to ESG for approval; the data is verified using both the raw data and the calculated data from the LIQTOTAL spreadsheet. The completed discharge form is kept in Lifetime records with copies going to the Central Control Room (CCR) and ESG.

- Gaseous discharges

Discharges of radioactivity via the contaminated vents are sampled continually using the CV stacks. The resulting samples are analysed three times per week and the data are used to report total activities discharged and the trend activities as a measure of plant conditions.

The flow rates and mass of gas data are transferred manually from the cabinet to form; the volume remaining in each of the bubbler bottles is recorded on the sample form. As with the liquid samples all of the data are saved to the counters, each with a unique identifier for subsequent data recall. The data are then transferred manually from the paper records into LIMS. The paperwork is then sent to ESG where it is verified and the data entered in to the gaseous worksheet which is saved to a secure network that gets backed up regularly.

The reactor gas is sampled twice weekly and data are handled as detailed above. The reactor gas activities are used to account for any reactor blow downs, the CCR supply details of the amount of gas blow down and the route so that it can be accounted for in the monthly gaseous discharge report.

8.1.4 Reporting

For all liquid discharge results where the data exceeds the MDA it is reported as a positive result; where the result is at or below the MDA then the MDA is recorded as a positive number. At the end of each month the type and number of each discharge is checked and then the monthly report for SEPA is generated. The report details the total volume discharged and monthly total activity for ^{3}H, ^{35}S, ^{60}Co, other beta and alpha as well as the rolling 12 monthly total for the same isotopes and finally the type and number of discharges. The report extracts the data directly from LIMS; prior to publication it is verified and approved by ESG engineers and the ESG group head. The report has to be provided to SEPA within 28 days of the end of the month bring reported. The full report is scanned and entered into life time records and the signed original is sent to SEPA.

A gaseous discharge report is generated and sent to SEPA within 28 days of the end of the month. The report covers sampling equipment availability with details of which systems were unavailable and why, the monthly percentage availability and a rolling 12 monthly figure. The total activity discharged over the month and the 12 monthly rolling averages are presented along with the Annual limits for ^{14}C, ^{3}H, ^{35}S, ^{41}Ar, ^{131}I and Beta particulate. Details of each blow down are also presented; they include the total activity for the radionuclides detailed above as well as which reactor and the tonnage. The report is generated within the gaseous spread sheet; prior to publication it is verified and approved by ESG engineers and the ESG group head.

The full reports are scanned and entered into life time records; the signed originals are sent to SEPA. All paper records are maintained within the ESG office for several years and then transferred to the archives.

8.1.5 Quality assurance and control procedures

EDF Torness laboratory is not accredited and it provides analysis only for the nuclear power plant. Nevertheless it operates according to a well-defined and documented set of procedures, which detail the source of each sample, the frequency of testing, the requirement and scope of the analysis as well as the responsible persons and references to the appropriate documentation.

The laboratory equipment is calibrated and routine source checks are carried out as detailed in the operation documents as follows:

- Liquid Scintillation Counters

Daily checks include a self-normalisation/auto-calibration (SNC) which is performed using two unquenched sources and an unquenched background. Measurement of this SNC set is used to calibrate the instrument and set the zero quench point. Traceable ^{3}H and ^{14}C standards are run on a daily basis on each LSC. The results obtained (decay corrected activity and % efficiency) are recorded and only if they are within an acceptable range from the reference value (+/- 10%) is the LSC then used for the analysis of samples. Finally a fresh deionised water background is prepared to check for active contaminants in the scintillant and deionised water supply. All of the results are maintained in the lab. Quench sets are prepared, counted and associated with the relevant protocol; the quench correction allows maximisation of the counting efficiency for the chosen counting regions.

- Gamma Spectrometers

A traceable mixed gamma source is used to prepare a number of standard sources. These standards are used to calibrate the gamma spectrometers (both in Energy and Efficiency) as required. The standards are replaced every 18 months. A weekly check is carried out using one of the prepared standards; only if the counted activity is within 5% of the reference activity is the gamma spec used to count samples.

- Alpha/Beta castles

Each lab has a set of ^{241}Am and ^{36}Cl standards that are used to check the responses of the alpha and beta castles respectively.

8.1.6 Participation in inter-comparison exercises and proficiency tests

Samples of both FDT and TET quarterly composites (liquid) are sent to National Nuclear Laboratories (NNL) and SEPA's monitoring contractor (currently Public Health England) for inter comparison studies. The NNL data is collated by GEM to look at the fleet performance and the PHE data is collated by SEPA.

The samples are prepared as follows:

- FDT discharges

Every month a proportional one litre sample is prepared (based on the total m^3 discharged). After analysis the sample is removed to contribute to the quarterly bulk (1 ml per m^3 discharged). This is stabilised with an equal volume of 2M Nitric Acid. At the end of the quarter the sample is analysed in house, results are captured in LIMS; samples are also sent to NNL and SEPA. The in-house results are sent to SEPA and GEM, the paper records are maintained with the ESG.

- TET discharges

Each tank is analysed individually; after analysis a sample is added to the bulk bottle (10 ml of the 1:1000 dilution per m^3 discharged). At the end of the quarter the bulk sample is analysed, results are captured in LIMS. As above the samples are sent to NNL and PHE as are operator in-house results.

Trending of the NNL data is carried out by GEM and discussed at the peer group (Discharge and District Survey – DADS).

There are currently no inter-comparisons undertaken with gaseous samples.

Torness occasionally participates in the National Physical Laboratory (NPL) Environmental Radioactivity Proficiency Test Exercises (PTE's), these provide a traceable mixed low level gamma standard to the station, once analysed the gamma spectroscopy results are sent to NPL, which provides a report detailing the accuracy of activity determination.

8.2 REGULATOR'S LABORATORY FOR DISCHARGE SAMPLES

The regulators commercial laboratory for discharge samples is currently PHE CRCE Glasgow, which is also SEPA's contractor for the collection and analysis of environmental and food samples around Scotland to satisfy the requirements of SEPA, FSS and Scottish Government. PHE is employed in this capacity under a commercial arrangement to SEPA. The laboratory is presented in section 6.2.

In general, for discharge samples, sample collection is undertaken by the site operator. No sample preparation is required and samples are analysed as received. Discharge samples are often diluted by the operator to reduce activity concentrations. The dilution factors are provided with the sample. PHE corrects measured analytical results on the diluted sample using the provided dilution factor to report result in terms of activity concentration of the original sample (i.e. the sample before dilution was applied).

Once the effluent samples have been received and any necessary dilutions have been applied they are subject to the same analysis procedures as routine environmental samples which is reported in section 6.2.

9 VERIFICATIONS

9.1 MONITORING OF RADIOACTIVITY IN THE ENVIRONMENT AROUND THE TORNESS NPP

9.1.1 On-site environmental monitoring

One dry cloth air particulate collector, of which there are a total of 20 on and off site was visited. The cloth, approximately 25 cm in height is cut from a roll and wrapped around 3 bars to form a triangular sampling area situated roughly 2.5m above ground. The sampler is located in the "no man's land" between the outer and inner high security fences. This is the sole method of analysing the air compartment around the site. A TLD, housed in a Seibersforf holder was also at the same location.

Direct radiation shine is continuously measured at 12 points on the site boundary, each consisting of 2 gamma tubes placed horizontally on a lead tray, principally along the on-site roadways surrounding the reactors. Data can be accessed on a limited number of workstations, notably in the control room and in the emergency centre. An annual function check is carried out using a known activity source. Three alarm levels are incorporated. Data is uploaded to the central server every 20 seconds and the values are expressed in nGy/h. Weather data is obtained from the nearby weather station at Crowhill. A similar system exists to detect abnormal levels of CO_2 in the surrounding air which could indicate a leak of CO_2 from the reactor.

No remarks.

9.1.2 Mobile measurement systems

The operator has 3 vehicles which can be used to take measurements both on and off site during an emergency situation. During the verification one was housed in the garage and another one was taking part in an emergency exercise. The third vehicle was being upgraded. In the event of an emergency the vehicles are dispatched to fixed points, from where they take measurements. These points have been selected to assess areas most likely to be impacted in the case of a release, taking a number of parameters, most notably the dominant wind direction into account.

The vehicle seen was comprehensively equipped to ensure the necessary on or off site monitoring in the event of an emergency. The Maypack (an activated charcoal filled canister) used for air sampling was demonstrated and the initial measurement carried out using a beta castle explained. If more detailed analysis is required this can be done in the on-site laboratory using gamma-ray spectrometry. The on-board beta castle is calibrated annually and a monthly function test carried out.

All communications, (voice and data) are performed via a secure network, the Nuclear Industry Airwaves System (NIAS). An annual emergency exercise is carried out in order to maintain efficiency and to test procedures. A generic emergency handbook exists covering all EDF sites[10].

No remarks.

9.1.3 Off-site environmental monitoring

The closest automatic air sampler to the NPP is situated in the 3 km zone and located on the outer wall of a barn. Sampling on a 90 mm disk shaped filter takes place over a 30 day period corresponding to sampling volume of air in the range of 2500 to 3000 m^3. In the event of a power cut the apparatus has an auto restart function and data can be stored for later recovery. The units are regularly calibrated by the manufacturer, Munro. A study is underway to investigate whether high volume air samplers in use at other sites could be adapted for use here, one major concern being noise as the current samplers are located in built up areas.

The verification team was informed that SEPA and CRCE Glasgow are looking into options to improve the reliability of the air sampler units by possibly installing a telemetric system using the mobile telephone network. This system would automatically report malfunctions and allow resetting and restarting the air samplers. An alternative option would be to refurbish the samplers with brushless electric motors.

A dry cloth collector and a TLD, identical to those seen on site were observed in the 5 km zone in a hedgerow along a quiet country road.

In accordance with the design of the RIMNET gamma dose monitoring network the stations are not located in proximity to nuclear installations and thus no stations were visited in the course of the verifications.

No sample taking was scheduled during the visit, neither by EDF or the regulator. Skateraw beach, in the immediate vicinity of the NPP was visited. EDF collects seawater and winkles and measures the beach gamma dose rate, whilst the regulator monitors the tidal beach gamma dose rate. No sampling of ground water is undertaken in the vicinity, all water comes from a reservoir some distance from the site where samples are taken.

The verification team supports the work of SEPA and CRCE Glasgow to improve the reliability of air sampling systems.

9.2 MONITORING OF RADIOACTIVE DISCHARGES AT THE TORNESS NPP

9.2.1 Liquid discharges

The monitoring system for radioactivity in liquid discharges in the Torness NPP consists of on-line monitors and sampling arrangements for the TET, FDT and blowdown discharges. The verification team visited the following facilities in order to verify their availability and functionality:

- FDT tanks

There are three FDT-tanks, all of them located in the -5.5 m level. The tanks are made of concrete; volumes are 70, 75 and 82 m^3. Two discharge pumps are available for each tank. Locked sampling cabinets are installed on each tank for sampling the tank content before each discharge. There are no automatic cut-off monitors on the discharge lines.

- TET tank sampling

Sampling from a TET-tank is carried out by the plant laboratory staff. It involves initial flushing of the sampling line (2 minutes), collection of a 300 ml recirculated sample and flushing of the cabinet with

[10] https://www.EDFenergy.com/sites/default/files/section_015.pdf

clean water. A sampling sheet with tank identification info is filled for each sample. The sample line valves are locked to avoid accidental discharge through the sample line or erroneous sampling from a wrong tank.

- FDT tank sampling

Sampling from the FDT tanks is identical with the TET tank sampling. Two one litre samples are taken, one for radiological and one for biological analysis. The tanks are all recirculated prior to sample collection, the flow and duration of the recirculation is set such that the whole tank will be mixed to ensure collection of a representative sample. TET is run for a minimum of 2 hours and FDT a minimum of 3 hours.

- Proportional discharge samplers

Proportional samplers attached to the FDT-tank discharge lines (there is no proportional sampler on the TET-discharge lines) take a 1 litre sample of each tank discharge automatically. These samples are normally not analysed, but they are kept for 24 hours to provide an additional back-up sample for the pre-discharge sample (which is the official tank sample). There is one automatic sampler for each FDT discharge line.

- AETP control room

The AETP control room is the place where all liquid discharge operations are carried out. The main control room authorises the tank discharge after having received the pre-analysis results and provides the necessary key for opening the discharge line. The actual discharge time window depends on the tides; sea tide tables are available for the time determination.

- Sea discharge line

The discharge line from the AETP to the sea is contained in a concrete trench, which is equipped to detect leaks and sumps for leakage collection. At the discharge line outlet the liquid discharges are mixed with the plant cooling water outflow.

No remarks.

9.2.2 Gaseous discharges

The monitoring system for radioactivity in gaseous discharges in the Torness NPP consists of on-line monitors and sampling arrangements on several discharge points. The verification team visited the following facilities in order to verify their availability and functionality:

- AETP ventilation gas sampling cabinet

The gas sampling cabinet (LEH 0-845) at the AETP receives a bypass gas flow from the building ventilation outflow. It is equipped with a fiberglass particulate filter, active charcoal filter for iodine sampling and a bubbler trap for ^{3}H and ^{35}S sampling. Three samples are taken each week. The particulate filter is installed inside the main ventilation line on a special filter holder, not on the bypass sample line.

There are two gas pumps and a recording gas flow control system. The total flow in the stack is measured once a year in order to determine the nominal gas outflow volume.

- GAM system

The GAM system (LEH 1-910) is equipped with an Ortec HPGe detector coupled with Canberra analogue electronics modules (ADC, amplifier and an HV-supply). The CO_2 flow is collected from 4 different points in the reactor at 1 bar pressure. The activity information from this monitor is transferred to the control room for early detection of high activity levels in reactor coolant gas, which would signify a fuel leak. There is one GAM system for each reactor.

There are arrangements for controlling the efficiency and energy stability of the systems, but the resolution (FWHM) is controlled only occasionally. The computer controlling both GAM-systems is an old Micro-VAX computer, which is outdated but operational.

If the GAM system fails, the plant laboratory can carry out manual sampling using gas bottles.

The verification team was informed that all GAM systems are scheduled to be equipped with digital electronics in 2017, the HPGe-detectors will remain the same.

- Auxiliary blowdown activity monitor cubicle

The auxiliary blowdown activity monitor cubicle (LEH 0-836) is located in the reactor hall. The system is identical to other gas monitor cubicles, including a rolling particulate filter, active charcoal Iodine cartridge, a bubbler trap sampler and a flow measurement system. All samples are collected three times each week. A filter paper removal demonstration was provided to the verification team.

- Outage monitor cubicle

The outage monitor cubicle (R1VAAE) is used only during plant outages. Functionally it is similar to all other gas monitors cubicles.

- R2CD cubicle

The R2CD gas monitor cubicle monitors the ventilation discharge from the reactor hall. It is operated continuously.

The gas pump of this unit was being replaced. Verification team was informed that this will be done on all gas monitors cubicles, because the old sample pumps are at the end of their lifetime.

> *Verification team recommends modernisation of the GAM-systems, in particular the computer controlling the systems. In this context, consideration should be given whether there is a need to install additional back-up systems for the GAM monitors.*
>
> *As a matter of good laboratory practice, the verification team recommends regular control and long-term trend monitoring of the HPGe-detector resolution (width of the ^{60}Co peak at 1332 keV).*

9.2.3 Control room

The plant control room receives the discharge sheets and authorises the liquid FDT and TET discharges. There are also monitors for the gaseous discharges, readings of the gamma radiation monitors installed on the site fence and meteorological information. GAM system alarms are received in the control room in the event of a fuel leak (^{133}Xe activity in the CO_2).

> *No remarks.*

9.3 ASSOCIATED ANALYTICAL LABORATORIES

9.3.1 TNPP base room laboratory for radioactive effluent samples

Initial FDT sample analysis is performed in the base room laboratory. Samples are registered on paper log sheets. Sample containers, their labelling system and the associated work instruction were presented to the verification team.

The base room equipment consists of one Ortec HPGe gamma spectroscopy system (HPGe detector and a digital electronics unit) and one Hewlett-Packard Liquid Scintillation Counter (Tri-Carb 2900TR). Commercial mixed nuclide liquid standard solution (1 litre) is available for calibration of the gamma spectroscopy system. Regular check procedures are in place for detector energy and efficiency stability, but not for the resolution (FWHM).

As a matter of good laboratory practice, the verification team recommends regular control and long-term trend monitoring of the HPGe-detector resolution (width of the ^{60}Co peak at 1332 keV).

9.3.2 TNPP radiochemistry laboratory for radioactive effluent samples

The TNPP radiochemistry laboratory is not accredited, but it operates according to an approved quality system and has written work instructions for each analysis. The analysis processes have been standardised across the whole fleet of EDF AGR reactors.

Upon receipt the samples are recorded in a log sheet and in the laboratory database. Nuclide analysis is performed using two HPGe gamma spectroscopy systems (electrically cooled Ortec with DSpec digital electronics). Typical counting time for FDT samples is 60 000 seconds. Calibration of the systems (energy and efficiency) is based on commercial multinuclide standards that are specific to the various measurement geometries (liquid sample, gas sample or filter paper).

For alpha and beta counting the laboratory has two Hewlett-Packard Liquid Scintillation Counters (Tri-Carb 2900TR) and individual total alpha and total beta counters.

The laboratory operates in close connection with other EDF plant laboratories and there are some intercomparison activities with regulators laboratory, but apart from that the laboratory does not participate in proficiency tests or intercomparison activities. The verification team notes that participation in such exercises at international level would further strengthen the analytical quality of the laboratory.

In order to maintain constant analytical quality level, the verification team recommends more intensive participation in proficiency tests and intercomparison exercises.

9.3.3 TNPP laboratory for environmental samples

The building housing the laboratories has a separate room dedicated to sample receipt, which can be partitioned by a temporary barrier in the event of an emergency situation when potentially higher activity samples may be expected. All staff delivering samples change their outer clothing before entering to avoid any contamination which they may have picked up in the field.

At the time of the verification there was only one laboratory technician, employed by an external contractor though arrangements are in place for him to be replaced as necessary by a colleague from Hunterston where procedures are very similar. This is a mutual arrangement. In a real emergency situation EDF would ensure that sampling was carried out but the analysis could be subcontracted to an approved laboratory.

In the case of samples, such as crab and lobster, where there is only 1 sample per quarter these are not labelled as the analysis will be done before the next quarter's sample arrives. Where there are multiple samples of a particular type, e.g. winkles the samples are individually labelled. All equipment, such as scales, ovens, driers, crushers etc. were available for sample preparation.

A tick list on the wall is used to display information concerning samples, from arrival to entry of the analysed values in the LIMS. At the time of the visit it showed data for the Q3 of 2016 showing type, ID, description, collection and preparation - followed by further columns displaying analysis type (gamma, beta ^{35}S, ^{14}C), gamma calculation and LIMS.

A whiteboard is extensively used to record information concerning samples being analysed, with the risk that this information could inadvertently be erased although access to the laboratory is limited to authorised personnel. This information was not recorded in a logbook or other more permanent form.

Two HPGe detectors are available in the laboratory and efficiency calibrations have been carried out for the 26 most common geometries. A control sample is run every Monday and the results logged, though no trending is established. Hunterston have such a system in place and at Torness implementation is under way.

The Berthold alpha/beta counter had 2 chambers which were not working, though the remaining 8 chambers are adequate for day to day needs. As a general rule maintenance incidents involving instruments are not systematically logged.

Appropriate standards are available for calibration of all instruments. Samples are retained for 2 years on a rolling basis after analysis.

Currently results have to be printed and then manually entered into the LIMS and the analysis protocol and these are then cross checked. Nevertheless this could result in erroneous values being reported where the same wrong value is recorded in both systems. The PC which runs the LIMS is backed up automatically on a regular basis.

Overall the laboratory, though displaying shortcomings in some areas is considered broadly fit for purpose. However, the verification team would suggest implementing a more secure and permanent system of recording sample progress. Furthermore trending of instrument calibration should be implemented, together with logging of instrument maintenance problems. In this respect integrating the laboratory in to the already existing LIMS system would be an asset to facilitate all record keeping.

9.3.4 Regulator’s laboratory for environmental and discharge samples

The PHE CRCE laboratory in Glasgow carries out analysis of the environmental samples taken under a commercial contract to SEPA in the surroundings of the TNPP. The laboratory is accredited according to ISO 17025 standard. It is well equipped for radiological analysis of environmental sample and drinking water – the equipment includes 8 gamma spectroscopy systems (Canberra), total alpha/beta counters (Canberra/Tennelec), 72-chamber alpha counter (Canberra), Liquid Scintillation Counter (LKB Wallac) and an ICP-MS (Agilent Technologies). Typically samples are kept for 6 months after analysis, and then discarded.

Arrangements have been made also for carrying out analysis of an increased number of contaminated samples in the event of a radiation emergency. In line with the accreditation requirements, the laboratory participates in several international intercomparison exercises annually (see Annex 5).

No remarks.

10 CONCLUSIONS

All planned verification activities were completed successfully. The information supplied in advance of the visit, as well as the additional documentation received during and after the verification activities, proved very useful.

The information provided and the verification findings lead to the following observations:

(1) The verification activities that were performed demonstrated that the facilities necessary to carry out continuous monitoring of levels of radioactivity in the air, water and soil on and around the Torness NPP site are adequate. The Commission could verify the operation and efficiency of a representative part of these facilities.

(2) The verification activities that were performed demonstrated that the facilities necessary to carry out continuous monitoring of levels of radioactivity in the gaseous and liquid discharges at the Torness NPP site are adequate. The Commission could verify the operation and efficiency of a representative part of these facilities.

(3) A few recommendations and suggestions are formulated, in particular as regards sample management at the Torness NPP environment laboratory and modernisation of the gaseous discharge on-line monitoring equipment. Notwithstanding these recommendations the verified parts of the monitoring system for environmental radioactivity and the monitoring arrangements in place at the Torness NPP are in conformity with the provisions laid down under Article 35 of the Euratom Treaty.

(4) The verification summary is presented in the 'Main Conclusions' document that is addressed to the United Kingdom competent authority through the Permanent Representative of United Kingdom to the European Union.

(5) The Commission services request a report on the implementation of the recommendations by the United Kingdom authorities and about any significant changes in the set-up of the monitoring systems before the end of July 2018. Based on this report the Commission will consider the need for follow-up verification.

(6) The verification team acknowledges the excellent co-operation it received from all persons involved in the activities it performed.

ANNEX 1

VERIFICATION PROGRAMME

Torness NPP discharge and environmental monitoring and the environmental radioactivity monitoring network in the vicinity

24 – 27 October 2016

Day/date	**Time**	**Team 1**	**Team 2**
Monday 24 October	14.30 – 17.00	Opening meeting with National authorities in Edinburgh Presentations: Radioactive National Bodies in UK on roles and responsibilities, SEPA site regulation and monitoring of the environment	
Tuesday 25 October	08.30 – 9.30	Site induction and dosimetry	
	9.30 – 10.00	Opening meeting with Torness NPP representatives Presentations: EDF as a corporate body, Site specific information AGR’s, Environmental monitoring programme and assessment	
	10.00 – 12.30	Verification of liquid discharge monitoring	Verification of operator's and regulator's on-site and off-site environmental monitoring and stations of national monitoring programme in the vicinity
	13.00 – 17.00	Verification of gaseous discharge monitoring	
Wednesday 26 October	9.00 – 16.00	Visit to laboratories dealing with analysis of discharge samples	Visit to laboratories dealing with analysis of environmental samples
	16.00 – 17.00	Closing meeting/debriefing with NPP representatives	
Thursday 27 October	09.00 -12.00	Visit to regulators lab at PHE (Glasgow)	

ANNEX 2

TORNESS NPP CONTAMINATED VENTILATION SYSTEMS

<table>
<tr><th>Contaminated Ventilation System</th><th>Intake locations and common discharge points</th><th>Discharge height/location</th></tr>
<tr><td>Reactor 1, common discharge (R1CD)</td><td rowspan="2">Extracts from five separate areas:
• secondary shutdown room contamination extract
• bypass gas (reactor coolant processing) system contamination extract
• quadrant A and B contaminated extract
• quadrant C and D contaminated extract
• pile cap contaminated extract.
each with independent ducting route the possible contaminated return air to a common discharge stack at level 07 (32m)</td><td>77 m</td></tr>
<tr><td>Reactor 2, common discharge (R2CD)</td><td>77 m</td></tr>
<tr><td>Fuel handling building (FHB)</td><td>Extracts potentially contaminated air from:
• fuel handling building
• glove box enclosures
and returns the two separate air systems to a common discharge stack at level 05 (20.1 m)</td><td>48 m discharge louvre on the roof of the central control room (CCR)</td></tr>
<tr><td>Fuel pond (FP)</td><td>Extracts potentially contaminated air from:
• irradiated fuel containment
• cooling pond area
the two systems merge at 12.5 m into a common discharge stack</td><td>48 m through a discharge louvre</td></tr>
<tr><td>In Service Inspection room ventilation (ISI)</td><td>H&V contaminated ducting draws air from:
• ISI contaminated extract fan room
• contaminated extract filters 1 and 2
• fuel machine maintenance room
• A-type sub change
• equipment store areas
• test and training facilities areas
• remaining areas in the ISI
• fuelling machine maintenance complex.
The ducting joins the common contaminated discharge stack at 52.0 m level</td><td>77 m through a discharge louvre</td></tr>
<tr><td>Gas circulator maintenance workshop (GCMW)</td><td>H&V contaminated ducting draws air from:
• circulator storage area
• decontamination bay
• contaminated extract filter room
• contaminated extract fan room
• loading bay areas
The air is drawn off through filters to the contaminated common discharge stack located at 11.3 m level</td><td>18 m</td></tr>
<tr><td>Active effluent treatment plant (AETP)</td><td>Areas covered by the system are:
• contaminated ventilation extract system
• drying tumbler contaminated ventilation extract system (Active laundry)
They combine at 10.5 m level</td><td>22 m</td></tr>
</table>

Contaminated Ventilation System	**Intake locations and common discharge points**	**Discharge height/location**
Active solid waste building (ASWB)	The contaminated system comprising: • buffer store • container store • medium active waste processing/store • waste oil treatment • active waste oil storage. They all then join the main contaminated extract stack at 5.5 m	22 m
Auxiliary carbon dioxide blow down (AXBD)	Used to blow down: • BPGP • Recombination Unit • Hot gas releases • Fuelling machine • Buffer Store • Gas Circulator Oil Filter The contaminated gas then passes into the common exhaust discharge stack at 13.5 m	76 m charge hall roof
Reactor 1 main gas blow down system	Reactor 1 vessel content	77 m
Reactor 2 main gas blow down system	Reactor 2 vessel content	77 m
Reactor 1, vessel access ventilation (R1 VAAE)	The vessel access air extract system works with the purge air system to ventilate the vessel for outage work, when CO_2 is replaced with air. It requires a spool piece to be fitted at the 2.5 m level reactor relief valve enclosure prior to instatement of the VAAE system.	75 m
Reactor 2, vessel access ventilation (R2 VAAE)		75 m

ANNEX 3

TORNESS NPP LABORATORY EQUIPMENT

Equipment	Model	Serial Number	Location	Calibration
Liquid scintillation counter (LSC)	Perkin Elmer, Tricarb 2900	422558	RCL1	Isotech Annual Service contract (included call off)
	Perkin Elmer, Tricarb 2900	104013	RCL2	
	Perkin Elmer, Tricarb 2900	100768	Base room	
Gamma Spec – High Purity Germanium (HPGe) detector	GEM-15190-P	050602	RCL1	Ametec service contract, annual service and call off for repairs
	GEM30P4	120122	RCL2	
	GEM-30xxx-P	40-TP11562A	Base room	
Gamma Spec – Digital Gamma-Ray Spectrometer	DSPEC+	104	RCL1	
	DSPEC+	105	RCL2	
	DSPEC-jr-2.0-POSGE	26865	Base room	
Gamma Spec – Electrical cooling system	CFG-X-COOL-II-230 and CryoSecure	50602 No. 110	RCL1	
	CFG-X-COOL-II-230 and CryoSecure	20202 No. 109	RCL2	
Alpha Castle	Canberra alpha drawer and SC105 scaler	956012-1, No.495	RCL1	Annual calibration and service carried out in-house
	Canberra alpha drawer and SC105 scaler	956012-1, No.494	RCL2	
	Canberra alpha castle and Mini MFG 544	956012-1 No. 581 L0003343	Base room	
Beta Castle	Canberra beta castle and JCS1880 scaler	956025-1, No.419	RCL	Annual calibration and service carried out in-house
	Canberra beta castle and Mini MFG 544	956025-1 No. 400 L0003343	Base room 1	
	Canberra beta castle and JCS1880 scaler	956025-1 No. 398 580	Base room 2	
Sampling RIG (5 trolleys available)	AM Sensors Ltd, sampler trolley system		RCL (gas lab)	Annual calibration and service from on-site team
Fume hoods	2		RCL	Service contract in place (Chemistry)
	1		Base room	
General Laboratory Equipment	i.e. Pipettes, Balances, pH meters etc		RCL and Base room	

ANNEX 4

SAMPLE MEASUREMENTS AT PHE CRCE GLASGOW

- Gamma spectrometry

After any required pre-treatment, samples are transferred to a standard geometry container. Pre-treatment may include concentration by evaporation (water samples) or freeze drying and homogenisation (organic samples).

Samples are counted on high purity germanium detectors over a calibrated energy range of 60 to 2000 keV. The detectors are calibrated against mixed nuclide sources on national traceability. Spectral analysis is undertaken using Canberra Genie software packages.

Counting times are typically in the range 4 – 16 hours. The radionuclides reported are those listed in the environmental monitoring programme (^{7}Be, ^{54}Mn, ^{58}Co, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{95}Zr + ^{95}Nb, ^{106}Ru, ^{110m}Ag, ^{125}Sb, ^{134}Cs, ^{137}Cs, ^{144}Ce, ^{154}Eu, ^{155}Eu, ^{241}Am, ^{40}K).

- Total alpha/beta activity
  - *Water samples*

Sub-samples of water samples are evaporated onto stainless steel planchets. The activity of the residue is determined by simultaneous alpha/beta particle counting on gas-flow proportional counters. All detectors are calibrated against standards of national traceability. Counting times are typically 240 – 360 minutes.

  - *Solid samples*

Samples are dried, ground and sieved to produce a homogeneous powder. A planchet is filled with a sub-sample of the homogenised material. The activity of the sample is determined by simultaneous alpha/beta particle counting can be done on gas-flow proportional counters. All detectors are calibrated against in-house solid standards prepared from standards of national traceability. Counting times are typically 240 – 360 minutes.

- Tritium analysis
  - *Water samples*

Aliquots of samples are distilled at ambient pressure. An aliquot of the middle fraction of the distillate is removed and activity assessed by liquid scintillation counting. The counter is calibrated against tritiated water traceable to a national standard. Counting times are typically 240 – 720 minutes.

  - *Solid samples*

A portion of the sample is placed in a silica combustion boat in a commercially available pyrolyser (Raddec Pyrolyser-6TM). The sample is dried under an air flow then the residue combusted under a pure oxygen flow at temperatures up to 600°C. The water produced is collected and the activity assessed by liquid scintillation spectrometry. Counting times are typically 360 – 720 minutes.

- ^{14}C analysis (aqueous and solid samples)

A portion of the sample is placed in a silica combustion boat in a commercially available pyrolyser (Raddec Pyrolyser-6TM). The sample is dried under an air flow then the residue combusted under a pure oxygen flow at temperatures up to 600°C. The CO_2 produced is trapped in a commercial reagent (Carbosorb E+, WallacTM), a suitable scintillation cocktail added and the activity assessed by liquid scintillation counting. The detectors and chemical recoveries are assessed against ^{14}C-labelled glucose traceable to a national standard. Counting times are typically 360 – 720 minutes.

- ^{32}P analysis

After suitable sample pre-treatment and extraction, phosphorous in the sample is precipitated as ammonium phosphomolybdate. The precipitate is dried and a known amount dissolved in a suitable scintillation cocktail for measurement of Cerenkov radiation by direct liquid scintillation counting.

Sample recovery is determined gravimetrically after mass dilution of a second aliquot of the sample spiked with a known amount of ^{32}P. Counting times are typically 240 -360 minutes.

- ^{35}S analysis
    - *Water samples*

The sample is pre-concentrated by evaporation in the presence of hydrogen peroxide and hydrochloric acid. The sulphur is separated from the sample as a sulphate by a hydroxide precipitation followed by ion exchange chromatography. Barium sulphate is precipitated from the ion exchange eluent. The precipitate is suspended in a suitable scintillation cocktail and the activity assessed by gel scintillation counting. Counting times are typically 240 – 360 minutes. Sample recovery is determined by analysing a second aliquot of the sample spiked with a known amount of ^{35}S.

- *Solid samples*

Solid herbage and soil samples are treated with Benedict's reagent to oxidise all sulphur species to sulphate. This is extracted, purified and precipitated as its barium salt. The ^{35}S activity in the barium sulphate is assessed by gel scintillation counting. Counting times are typically 240 – 360 minutes. Chemical recoveries are calculated by analysis of a paired sample spiked with ^{35}S tracer of national traceability.

- ^{90}Sr analysis

A portion of the sample is ashed (organic materials), leached (soils and sediments) or evaporated (aqueous) and the residue extracted with aqua regia then converted to dilute nitric acid. Strontium is separated by chelation chromatography (Triskem Sr-resin ™). After a suitable in-growth period, the daughter, ^{90}Y, is separated by precipitation as the oxalate salt and the beta activity assessed by total beta counting on gas flow proportional counters. Counting times are typically 240 minutes. Chemical recoveries are assessed by use of ^{85}Sr internal yield tracer. The detectors are calibrated against a ^{90}Sr source traceable to a national standard.

- ^{99}Tc analysis
    - *By low background Beta counting*

After suitable pre-treatment of sub-samples (ashed in alkaline conditions for solids, evaporated for aqueous), technetium is converted to pertechnetate by treatment with peroxodisulphate. It is separated by solvent extraction followed by electrodeposition onto a stainless steel disc.

- *By ICP-MS (inductively coupled plasma mass spectrometry)*

Samples are pre-treated in such a way as to convert the ^{99}Tc in the sample to a solution in 2% nitric acid and passed through a TEVA column to remove ^{99}Ru. The sample is taken into the ICP-MS and an argon plasma is formed. The plasma is sampled and the determinand ions are collected and measured by the mass spectrometer.

Both techniques determine chemical recoveries through the use of ^{99m}Tc as an internal yield tracer. The detector is calibrated against a ^{99}Tc solution traceable to a national standard.

- ^{129}I analysis

Where possible, gamma-ray spectrometry is used to quantify this nuclide directly in the sample matrix. Otherwise, iodine is separated by oxidation of iodide followed by solvent extraction of iodine. After back extraction and chemical reduction, iodide is precipitated as its silver salt. The activity of iodine radionuclides is then assessed by gamma-ray spectrometry. Chemical recoveries are determined by quantifying the gravimetric recovery of silver iodide. The gamma-ray spectrometer is calibrated with sources traceable to national standards.

- ^{210}Po analysis

For solid samples, after acid digestion of fresh samples (to prevent polonium losses) the leachate is converted to dilute hydrochloric acid. For liquid samples, the sample is evaporated to a small volume and converted with concentrated hydrochloric acid and then diluted with water. ^{210}Po is deposited onto a silver planchet in the presence of a mild reducing agent and its activity assessed by alpha spectrometry. Counting times are typically 24 – 120 hours. Chemical recoveries are determined by the addition of ^{209}Po as a yield tracer. The yield tracer is traceable to a national standard.

- ^{210}Pb analysis

After completion of the ^{210}Po analysis as described immediately above, ^{210}Po is deposited from the final solution a second time. The solution is then left for a known period of time to allow ^{210}Po to grow-in from the decay of ^{210}Pb in solution. The ^{210}Po is then re-deposited onto fresh silver discs and the activity of polonium isotopes determined by alpha spectrometry. Counting times are typically 24 – 120 hours. The activity concentration of ^{210}Pb can be calculated for the in-growth of the ^{210}Po daughter. Correction is made in case ^{210}Po is not completely removed from the initial solution.

- ^{234,235,238}U analysis

For solid samples (soils, sediments, vegetation) a sub-sample is ashed to remove organic components, them leached with aqua regia to solubilise the uranium. Aqueous samples are evaporated and the residues treated with aqua regia. The aqua regia extracts are converted to dilute hydrochloric acid. The uranium isotopes are separated by ion exchange chromatography followed by solvent extraction. After electrodeposition onto stainless steel planchets, the activities are assessed by alpha spectrometry. Counting times are typically 24 – 120 hours. Chemical recoveries are measured through the addition of ^{232}U as an internal yield tracer. The yield tracer is traceable to a national standard.

- ^{238,239,240,241}Pu analysis

For solid samples (soils, sediments, vegetation) a sub-sample is ashed to remove organic components, them leached with aqua regia to solubilise the plutonium. Aqueous samples are evaporated and the residues treated with aqua regia. The aqua regia extracts are converted to dilute nitric acid. The plutonium isotopes are separated by ion exchange chromatography. After electrodeposition onto stainless steel planchets, the activities are assessed by alpha spectrometry. Counting times are typically 24 – 120 hours. Chemical recoveries are measured through the addition of ^{242}Pu as an internal yield tracer. The yield tracer is traceable to a national standard.

Where ^{241}Pu is required, the plutonium on the planchet is re-dissolved and transferred to a suitable liquid scintillation cocktail. ^{241}Pu activity is determined by liquid scintillation counting, using the alpha activity in the counting vial as a yield tracer. Counting times are typically 240 mins. The α and β-regions of the spectrometer are calibrated against standards of national traceability (^{241}Pu and ^{239}Pu).

- ^{241}Am analysis

The initial stages of ^{241}Am separation are identical to those of plutonium. After the plutonium ion exchange chromatography stage, americium is further purified by solvent extraction and a further two ion exchange steps. Finally, after electrodeposition, ^{241}Am activity is assessed by alpha particle spectrometry. Counting times are typically 24 – 120 hours. Chemical recoveries are estimated by addition of ^{243}Am as an internal yield tracer. The yield tracer is traceable to a national standard.

- Salinity Measurements

Salinity measurements are made at the time of seawater sample collection using a suitable field salinity meter (Eutech Instruments Ecoscan Salt 6 Salinity Meter). The monitor is re-calibrated with standard solutions at time of use in the field.

ANNEX 5

INTER-COMPARISON EXERCISES AND PROFICIENCY TESTS IN WHICH PHE CRCE GLASGOW PARTICIPATED

- Procorad 2011 – Actinides (U, Th, Pu, Am) in urine and faecal ash intercomparison 2011.
- National Physics Laboratory – Environmental Radioactivity Intercomparison Exercise 2011.
- MAPEP 2011 ex 24 – Sr, Tc actinides (U, Pu, Am), ^{3}H, gamma emitting and stable metals in soil and water.
- EC wild bilberry powder intercomparison– Sr and gamma emitters in wild bilberry powder 2011.
- MAPEP 2011 ex 25 – Sr, Tc, actinides (U, Pu, Am), ^{3}H, total alpha/beta, gamma emitting and stable metals in soil, vegetation and water.
- MAPEP 2012 ex 26- Sr, Tc, actinides (U, Pu, Am), ^{3}H, total alpha/beta, gamma emitting and stable metals in soil, vegetation and water.
- Procorad 2012 alpha spec. spectrum interpretation exercise - Pu & U (radiometrics only).
- National Physics Laboratory – Environmental Radioactivity Intercomparison Exercise 2012.
- MAPEP 2012 ex 27 - Sr, Tc, actinides (U, Pu, Am), ^{3}H, total alpha/beta, gamma emitting and stable metals in soil, vegetation and water.
- IAEA-TEL-20121-03 – radionuclides unspiked water, soil and hay.
- MAPEP 2013 ex 28 - Sr, Tc, actinides (U, Pu, Am), ^{3}H, total alpha/beta, gamma emitting and stable metals in soil, vegetation and water.
- MAPEP 2013 ex 29 - Sr, actinides (Pu, Am), ^{3}H, total alpha/beta, gamma emitting and stable metals in soil and water.
- MAPEP 2014 ex 30 - Sr, actinides (Pu, Am), ^{3}H, total alpha/beta, gamma emitting and stable metals in soil and water and vegetation.
- MAPEP 2014 ex 31 - Sr, actinides (Pu, Am), ^{3}H, total alpha/beta, gamma emitting and stable metals in soil and water, vegetation and air filter.
- EC 2015 Reporting of the results for ^{137}Cs in air filters.
- MAPEP 2015 ex 32 - Sr, actinides (Pu, Am), ^{3}H, total alpha/beta, gamma emitting and stable metals in soil and water, vegetation and air filter.
- MAPEP 2015 ex 33 - Sr, actinides (Pu, Am), ^{3}H, total alpha/beta, gamma emitting and stable metals in soil and water and vegetation.
- Global Health Security Initiative Emergency Radionuclide Bioassay Lab Network 2016; and,
- MAPEP 2016 ex 34 - Sr, actinides (Pu, Am), ^{3}H, total alpha/beta, gamma emitting and stable metals in soil and water, vegetation and 'surprise' sample.