



Scottish Environment Protection Agency

SEPA's main aim is to provide an efficient and integrated environmental protection system for Scotland which will both improve the environment and contribute to the Scottish Ministers' goal of sustainable development.

**Radiological Habits Survey,
Rosyth Business Park, 2005**

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SUMMARY

This report presents the results of a survey, conducted in 2005, into the habits and consumption patterns of people living and working in the vicinity of the Rosyth Business Park (formerly Rosyth Royal Dockyard) which discharges gaseous and aqueous emissions to the atmosphere and the Firth of Forth respectively. The site also has sources of direct radiation. Potential exposure pathways for the site include consumption of locally sourced terrestrial and marine foods and occupancy of nearby dwellings and intertidal areas. The survey investigated all of these pathways and the data obtained on the consumption and occupancy rates of individuals are presented and discussed. Data were collected for 1193 adults and 35 children.

Food sources included locally caught and collected fish, shellfish, wildfowl, marine plants, local meat, poultry and eggs, local game, wild/free foods, wild fungi, honey and home/allotment grown fruit and vegetables. Occupancy habits included those related to residences and workplaces within 1km of the site centre, recreation and work activities over intertidal areas and handling of fishing gear and intertidal sediment. In the marine environment, the main activities were commercial and hobby fishing, boating/yachting, wild fowling, angling and bait digging. In the terrestrial survey area, farm production was predominantly arable with some farms producing beef cattle and lamb.

1. BACKGROUND

1.1 Regulation of radioactive waste discharges

There are generally three main sources of radiation exposure to members of the public from nuclear sites in normal circumstances: discharges of radioactive waste to the aquatic environment, discharges to the atmosphere and direct radiation from the site. Regulation of waste discharges is carried out under the Radioactive Substances Act 1993, (RSA93) (UK Parliament, 1993). Authorisations granted under RSA93 set limits on the quantities and types of radioactivity that are permitted to be released from the site. For discharges in Scotland, the Scottish Environment Protection Agency (SEPA) is the regulatory authority under RSA93. Sources of direct radiation from sites are regulated by the Nuclear Installations Inspectorate (NII) of the Health and Safety Executive (HSE).

1.2 The critical group concept

Radiological protection of the public is based on the concept of a critical group. The critical group is defined as the people who, because of where they live and their habits, receive the highest radiation dose from the site and its discharges. It is the assessed radiation dose to the critical group that is compared to relevant limits and constraints. If the dose to the critical group is acceptable, it follows that the lower doses received by other members of the public will be below any limits and constraints, and overall protection of the public from the effects of the radioactivity is provided. This survey provides information to assist SEPA in determining critical groups around Rosyth.

1.3 Dose limits and constraints

Assessed radiation doses to critical groups are compared to nationally and internationally agreed dose limits, recommendations and constraints.

The Radioactive Substances (Basic Safety Standards) (Scotland) Direction 2000 directs SEPA to ensure that the sum of doses of ionising radiation to the public does not exceed the limits set out in Article 13 of Council directive 96/29/Euratom (CEC, 1996) and that doses should be as low as reasonably achievable (ALARA), economic and social factors being taken into account. In connection with the latter, SEPA is directed to have regard to the following maximum doses which may result from a defined source, for use at the planning stage in radiation protection:

- a) 0.3 millisieverts per year from any source from which radioactive discharges are first made on, or after 13 May, 2000: or
- b) 0.5 millisieverts per year from the discharges from any single site.

Additionally, the Government accepts that, in general it should be possible to operate existing facilities within the 0.3 mSv per year source constraint.

2. THE SURVEY

2.1 Site activity

Discrete parts of Rosyth Business Park are designated as Nuclear Licensed Sites. Outside the Business Park to the north are a large number of buildings which are now rented out to private businesses. Rosyth finished nuclear military operations (decommissioning, refurbishment and refuelling of naval submarines) in 2003. At the time of the survey, current site activities included waste management, decommissioning of nuclear facilities and disposal of contaminated equipment to waste disposal facilities. Low-level liquid radioactive wastes were discharged into the Firth of Forth and gaseous waste discharges were made to the atmosphere.

2.2 Survey aims

The Centre for Environment, Fisheries & Aquaculture Science (Cefas) undertook the survey in August 2005 on behalf of SEPA (Cefas contract C2448 and SEPA contract R40067/PUR). The aim of the survey was to review habits related to public radiation exposure via aquatic, terrestrial and external exposure pathways resulting from routine radioactive emissions and direct radiation from the Rosyth site. The last full habits survey of the Rosyth site was by Cefas in 1999 (Caldwell *et al*, 2001). Data from this survey are currently being used for dose assessments in the Rosyth area.

Fieldwork was conducted in order to obtain site-specific habits data. These data, in combination with monitoring data, can be used to determine local critical group(s) and identify critical exposure pathways to the local population. General habits survey information for the area was also obtained.

Investigations were carried out to ascertain the following:

- External exposure activities, including angling, wildfowling and general recreational pursuits along the intertidal shoreline.
- Internal exposure from the consumption of food sourced from the aquatic and terrestrial environments.
- The production, use and destination of local produce.
- The extent of occupancy within 1km of the site centre.
- The extent of any unusual practices.
- The use of any natural resources from the aquatic environment (e.g. sand extraction, the use of seaweed as a fertiliser).

The survey team also collected information that could be used in the assessment of other pathways such as the inhalation of re-suspended radioactivity in sea spray, the inadvertent ingestion of contaminated seawater and contact with and/or inadvertent ingestion of contaminated sediments.

2.3 Survey areas

Different survey areas were selected to cover the aquatic, terrestrial and direct radiation pathways.

The aquatic survey area, shown in Figure 1, covered the Firth of Forth from Culross and Bo'Ness in the west to Burntisland and Granton in the east. This was the same area selected for the 1999 survey. However, because of limited observations, this area was extended slightly during the survey to include commercial fishing boats and salmon netters at Kincardine (west) and hobby fishing boats at Kinghorn (east). In effect the survey encompassed any activities taking part in, or seafood landings from the Firth between imaginary lines from Kincardine to Higgin's Neuk to the west and from Kinghorn to Newhaven to the east.

The terrestrial survey area, shown in Figure 2, was defined as the full circle to a radius of 5km from the site centre; this area is considered to encompass the main areas of potential deposition of gaseous discharges.

For the direct radiation area, again shown in Figure 2, the survey aimed to cover individuals residing and working within 1km of the site centre.

2.4 Conduct of the survey

Prior to the survey people with a local knowledge of the survey area were contacted for information on any aspects relevant to the exposure pathways. These included individuals connected with local diving, wildfowling and angling clubs, and local commercial and hobby fishermen, farmers, beekeepers and allotment holders.

The fieldwork component of the survey was carried out during the period 15th to 24th August 2005 by three members of staff from the Cefas laboratory at Lowestoft, according to techniques described by Leonard *et al* (1982).

On 16th August 2005, a meeting was held between representatives from Rosyth Business Park, SEPA and Cefas; this served to provide details about site operations, including waste disposal, and information about potential pathways and activities in the area. Further information was sought about wildlife studies and pest control measures in and immediately around the site; these animals could act as vectors for transporting radioactive materials off-site and are also potential food items for some individuals.

During the survey, interviews were used to establish individuals' consumption rates and occupancy rates relevant to all pathways and to obtain any general information of possible use to the survey. Using this information, a list of occupations and activities was built up to produce a picture of potential exposure pathways. Emphasis was placed on those individuals who were likely to be in the most exposed groups. These included commercial and hobby fishermen, wildfowling, allotment holders, beekeepers and farmers, and individuals living and/or working within the direct radiation survey area. It should be noted that the survey did not include site employees or contractors for either company for the proportion of their time they spent working on site. Their off-site activities outside these times, such as any consumption and occupancy relevant to the survey have been included in the survey data. Dose standards applicable to them whilst at work are different to those for members of the public.

3. METHODS FOR DATA ANALYSIS

3.1 Data conversion

The data collected during the fieldwork were recorded in logbooks. Information on individuals' consumption and external exposure rates was assessed and entered into a database. Each individual for whom information was obtained was given a unique identifier (the Observation Number) to assist in data sorting. Consumption data were converted to consumption rates in

kilograms per year (wet weight) of locally produced food. During the interviews, people could not always provide consumption rates in kilograms per year for food. In these cases, interviewees were asked to provide the information in a different format. For example, some estimated the size and number of items, e.g. eggs consumed per year, whereas others gave the number of plants in a crop or the length and number of rows in which the crop was grown per year. These data were converted to approximate consumption rates, in kilograms per year, using published produce weights (e.g. Hessayon, 1997 and Good Housekeeping, 1994), edible fraction data researched by Cefas and information supplied by the Meat and Livestock Commission. For the purpose of data analysis, foodstuffs were aggregated into food groups; the typical food groups used in surveys are shown in Table 1. All consumption and occupancy data in the text are rounded to 2 significant figures. In the tables and annexes, the data are usually presented to 1 decimal place. The exceptions are for values less than 0.05, which are presented to 2 decimal places in order to avoid them appearing as 0.0 and external exposure rates, which are quoted as integers.

3.2 Determination of critical groups

The critical group is determined by assessing doses that are representative of the most exposed individuals. The group will change according to the assessment being undertaken. Each assessment will have associated concentrations and/or dose rates distributed in space and time. This survey provides information that can be used to help define the critical group in an assessment but it does not constitute an assessment in itself. The terms critical group and critical group consumption rates are only used here for ease of presentation. They can only be established once a dose assessment using environmental monitoring data has been undertaken.

The habits data are structured into groups of food items or substrate types with similar attributes. For example, when considering terrestrial food consumption, all types of root vegetables are grouped together in a food group called 'root vegetables'. Similarly, for aquatic food consumption, all mollusc species are grouped as 'molluscs'. For external exposure over intertidal sediments, occupancy over a common substrate, (for example, mud) is chosen. The choice of a group of activities is made when it is reasonable to assume that consistent concentrations or dose rates would apply within the group. In addition to grouping of activities, ingestion data are structured into age groups because different dose coefficients can apply to different ages. The age groups used were: from 0 to 1.0 y of age (called 3 month old); more than 1.0 y to 2.0 y (called 1 year old); more than 2.0 y to 7.0 y (called 5 year old); more than 7.0 y to 12.0 y (called 10 year old); more than 12.0 y to 17.0 y (called 15 year old). Children over 17 are treated as adults. These age groupings are consistent with those used by ICRP (ICRP, 1996).

Ingestion pathways

Consumption rate data are presented for individuals and are further characterised in two ways to represent high rate consumers in each food and age group. Firstly, the 97.5 percentile rate is calculated from the observed data, for each of the food groups where consumption occurred, using the Microsoft Excel mathematical function for calculating percentiles. This 97.5 percentile rate is calculated for all age groups where consumption was noted. Secondly, the 'cut-off' method described by Hunt *et al* (1982) is used for each age group's observations for each of the food groups where consumption occurred. In this case, the rate representing high rate consumers is calculated by taking the arithmetic mean of the maximum value and all consumption rates observed within a factor of 3 of the maximum value (termed the lower threshold value). It accords with the principle expressed by ICRP (ICRP, 1984) that the critical group should be small enough to be reasonably homogeneous with respect to age, diet and those aspects of behaviour that affect the doses received.

In exceptional cases, the 'cut-off' method can result in only one member in the high rate group. In this case, judgement is used as to whether to include other individuals within the group. If it is decided appropriate to include other individuals, the next highest suitable observation is used to set the lower threshold but the top value is still included in the mean. Cefas have called the rate derived by the cut-off method the critical group rate for ease of

presentation though the term is not strictly correct. This is because the critical group can only be established when doses are determined taking into account all pathways.

Consumption data for aquatic foodstuffs are presented for adults in Tables 2 to 6, and for children in Tables 7 and 8. They are summarised in Tables 9 and 10 for adults and children respectively. For the purpose of comparison, values for 97.5 percentile and mean consumption rates based on national data, referred to as 'generic' rates in this report, are shown for aquatic foodstuffs for adults and 15 year old children (no 10, 5 and 1 year old or 3 month old children were noted to be consuming aquatic foods). Consumption data for terrestrial foodstuffs are presented for adults in Tables 12 to 25, and for children in Tables 26 to 33 and they are summarised in Table 9 for adults and 10 and 11 for children. Again, for the purpose of comparison, values for 97.5 percentile and mean consumption rates based on national data are shown for terrestrial foodstuffs for adults, 15 and 10 year old children (no 5 and 1 year old or 3 month old children were noted to be consuming terrestrial foods).

The critical group consumption rates for children have been calculated from the survey data. However, because few child consumers were identified the method should be viewed with caution. For assessment purposes, a theoretical approach may be taken where survey rate data for children's age groups are absent or limited. This involves taking the rates for adults, provided in Table 9, and scaling them by ratios shown in Table 41. The ratios have been calculated using generic 97.5 percentile consumption rates determined by MAFF and FSA (Byrom *et al* 1995, FSA, 2002 and Smith and Jones, 2003) for adults, 10 year olds and children aged 6–12 months.

External exposure in intertidal areas

A similar approach to ingestion pathways is used for occupancy and handling rates in intertidal areas (Tables 35 and 36 respectively). 97.5 percentile rates and critical group rates are determined for groups of activities or substrates with common attributes. In previous surveys a factor of 1.5, instead of 3, was used to define the cut-off value for intertidal occupancy and handling. However, it is now considered appropriate that the same factor as for consumption is used. The factor reflects variations in the doses likely to be received due to natural variations in the interaction of radiation with tissues caused by, for example, differences in anatomy.

Direct radiation exposure

Data for the direct radiation pathway are presented in Table 39 and are left in their detailed form for each individual at each location. Grouping of these data is not helpful at this stage in the assessment process when there is no definitive measurement or prediction of dose rate due to external radiation from the site.

A summary of consumption, occupancy, and handling rates for adults and children are presented in Annex 1 and Annex 2 respectively.

4. AQUATIC RADIATION PATHWAYS

The aquatic survey area is shown in Figure 1.

4.1 Aquatic survey area

Kincardine – Rosyth

On the north side of the Firth of Forth, below the A876 Road Bridge leading into Kincardine is a small concrete pier, which was used by anglers and the small Kincardine fishing fleet. The fleet consisted of three stow-net fishing boats and one licensed salmon netting boat. The license permits the owner to sweep-net for salmonids along a one-mile length of the opposite (south) shore of the Firth of Forth – an area known locally as Higgins Neuk Beat. The substrate at Kincardine was soft mud that extends east for approximately 5 km to Culross, passing the Longannet coal fired power station. Although no angling or other intertidal

activities were noted during the survey on this stretch, the survey team were told that angling for bass (*Dicentrarchus labrax*) occurred near the power station on occasions when this species turned up in reasonable numbers.

The bay at Culross had substrates of mud, sand and stones. Bait digging took place here and the area was popular with visitors, who walked along the shore front. Between Culross and Torry Bay the substrate was mainly mud and sand and dog walking was the only activity observed. Torry Bay was a popular location for wildfowling and the substrate was mostly composed of mud and sand with outcrops of rocks. Between Torry Bay and Charlestown the substrate was again mud and sand and the activities observed were walking and dog walking. The east and west piers at Charlestown sheltered numerous small boats, mostly yachts and pleasure craft. Time was spent by the owners on board their craft on maintenance and repair. The substrate in the harbours was thick mud. The foreshore from Charlestown to Limekilns consisted of rocky outcrops over a substrate of mud, sand and stones. Signs of bait digging was along this stretch of foreshore. There was a pier at Limekilns which served as a shelter for a number of yachts moored there. Maintenance work on these boats took place, mostly on dry land, away from the foreshore. A good position for angling was offered by the pier wall. Between Limekilns and the Rosyth Business Park there was an increase in shale type outcrop, however the base substrate remained the same; mud and sand.

Rosyth – Dalgety Bay

The area from Rosyth to North Queensferry was dockland or industrial complex with no public leisure activities noted. North Queensferry has a rocky promontory above narrow strips of shingle and occasional mud patches. Angling from this promontory was permitted even though construction work was taking place on the Forth Rail Bridge. There are two harbours at North Queensferry, one housed a boat club, the other, fronting the village had slipway access, where visitors could launch their boats. The boat club had a few dozen boats which members accessed at all states of tide, but mostly at high water. Several walkers and families were noted using the boat club grassed area. East of the promontory was Port Laing that had a sandy bay containing a few small boats used for pleasure activities. There was a marina at Inverkeithing, otherwise the area had limited access to anglers because of the surrounding industry. The Inner Bay at Inverkeithing opened into an expanse of mud and sand. There was a harbour at St. Davids Bay which had been redeveloped since the 1999 habits survey. Several boats, owned by anglers and hobby creel fishermen were present. Walkers frequently used the footpath around St Davids Bay and in the vicinity of Dalgety south pier, mussel (*Mytilus edulis*) beds were in evidence. There were also large quantities of winkles (*Littorina littorea*) amongst the rocks in St Davids Bay and a regular collector was observed and interviewed at this location. He said that on particularly low spring tides he also collected small numbers of queen scallops (*Chlamys opercularis*) from this location. Regular bait digging was also observed there. The substrate was mud and sand with numerous rocks and boulders.

Dalgety Bay had a large sailing club and was easily accessible to the many residences bordering the bay. The harbour area was mostly sand and rocks. Families and dog walkers made recreational use of this area. The bay is large and intersected by several channels.

There have been radiation surveys carried out by organisations contracted by SEPA and The Scottish Office, Central Research Unit at Dalgety Bay. The surveys have researched local activities of members of the public in the contaminated area and have also removed radium deposits associated with luminous aircraft instruments. The significance of this material occurring in the bay is still being considered by SEPA.

Dalgety Bay – Kinghorn

Aberdour Bay and Silversands Bay were both a mixture of sand and rocks and the areas afforded the opportunity for leisure activities such as picnicking, sunbathing and swimming. There was easy access to both bays via the village coastal roads. One mollusc collector said that he regularly gathered mussels from the rocks in Aberdour Bay. Burntisland has a large commercial dock, which provided a berth for one of the commercial fishing boats. East of

Burntisland was an extensive sandy area used by holidaymakers, dog walkers and local residents. Many people were observed sunbathing in the area and bait digging was evident by the large areas of recently dug substrate. Council workers engaged in beach cleaning activities also spent significant amounts of time there. Further east the villages of Pettycur and Kinghorn both had small harbours providing moorings for pleasure craft and hobby fishing/angling boats. At Kinghorn harbour, there were a few fishermen's huts and stacked up potting creels. The survey team regarded Kinghorn as the easterly boundary of the aquatic survey area on the north shore. East of Kinghorn, commercial fishing took place from Weymiss, Methil, and Pittenweem. Landings at these ports provided fish to consumers in the survey area, but these landings were not considered to be from the aquatic survey area and were excluded from the consumption data.

Granton – South Queensferry

The eastern breakwater at Granton harbour, was a popular location for anglers, especially for catching mackerel (*Scomber scombus*) during the summer months, but only one of the several anglers interviewed consumed any locally caught fish. On one occasion, a couple of families were seen spending time on the beach and in the sea to the east of the pier.

Granton Harbour was a large, busy harbour used by two yacht clubs. One, Royal Forth Yacht Club had approximately 300 members and 100 boats and the other, Forth Corinthians Yacht Club had approximately 50 members and 20 boats. All boats were used for yachting and sailing as no sea angling or fishing boats were allowed to moor in the harbour.

To the west of Granton Harbour the substrate was stony and no activities were observed during the survey. Midway between Granton Harbour and Cramond a large area called Drum Sands began and stretched approximately 7 km along the shoreline to Hound Point. At high tide, the beach was a relatively small area of shingle and sand but due to the large tidal excursion at Drum Sands, wet sand and muddy sand were exposed at low tide up to a distance of 2 km from the shore. Drum Sands was used by many walkers, dog walkers and families and a couple of people were seen swimming in the sea at high tide. One interviewee reported angling from the beach at Drum Sands.

Drum Sands was used by bait diggers who used spades to dig for lugworm from the muddy sand exposed at low tide. A couple of bait diggers also collected small amounts of cockles and mussels for bait from the same area. As the survey dates coincided with a period of exceptionally low tides, about 20 bait diggers were seen on one day collecting white ragworm and some razor shells from the sandy area at the water's edge near Cramond Island when the tide was at its lowest. The habitat for white ragworm is only accessible during very low tides, so this was an infrequent activity. All bait diggers interviewed during the survey were collecting bait to use themselves in angling matches taking place outside the survey area. No commercial bait digging took place within the survey area.

Cramond Island was a small, rocky island situated on Drum Sands, about 1.5 km offshore from the village of Cramond and linked to the mainland by a concrete causeway, accessible on foot at low tide. Several tourists and some locals were seen walking out to the island and one local family who were interviewed took children's fishing nets with them in order to collect peeler crabs from rock pools on the island to use for bait.

The River Almond discharged into the Firth of Forth at Cramond and there was a boat club located at the mouth of the river. The club had approximately 240 members and 90 boats. All boats except one were used for sailing and regular races were organised by the club. One hobby fisherman moored his boat in the River Almond at the boat club.

To the west of Hound Point was a stretch of stony, rocky shoreline, which could only be accessed on foot. No people were seen here during the survey.

South Queensferry – Bo'ness

South Queensferry was a village popular with tourists. The shoreline was stony and activities noted on the beach included litter picking and children playing. One individual collected king ragworm and a few lobsters from a rocky, sandy area under the Forth Rail Bridge

There is a slipway in South Queensferry called Hawes Pier. The slipway was used by a company ferrying employees from the mainland to the oilrig in the Firth of Forth, by the RNLI and by a company running boat trips to Inchcolm Island, a nature reserve run by Scottish Natural Heritage. The boat trips ran for seven months per year and on busy days the company took over 400 people to the island and back. The South Queensferry RNLI station had a team of 19 people who spent time on the water training and responding to emergency incidents.

A small harbour in South Queensferry housed several small boats, one of which was a hobby potting boat. All other boats were used for sea angling or sailing. The harbour was intertidal so at low tide the boats were grounded on mud. Anglers fishing from the harbour wall were interviewed but none were noted to consume any of their catch.

Port Edgar was a large marina complex situated immediately to the west of the Forth Road Bridge. Several organisations were based at Port Edgar including a yacht club, a sailing centre, a sailing school, a sea cadets training centre and HM Coastguards. There was a large marina where several hundred yachts and a few sea angling boats were moored and because the marina was intertidal, some boats were grounded on mud for short periods of the tidal cycle. One boat was occupied as a place of residence for several months of the year.

A mainly muddy shoreline stretched westwards from Port Edgar to Blackness. To the west of the castle at Blackness was Blackness Bay where there was a boat club with about 100 members and 40 boats. As at Granton, all boats were used for sailing rather than sea angling or hobby fishing. At low tide, Blackness Bay was a vast expanse of mud used by wildfowlers, mainly to shoot widgeon but also some mallard, teal and greylag geese. At high tide, there was a small beach with sandy and stony areas. A few people were seen there and the activities noted were beachcombing, walking, playing and bait digging. Mussels were seen in the bay but no collection was reported. One couple reported consuming small quantities of samphire (*Salicornia europaea*) collected from Blackness Bay.

From Blackness to Bo'ness the shoreline consisted of fine mud banks with little vehicular access. The survey team heard no reports of activities such as baitdigging taking place on this stretch of mud. The Upper Forth Boat Club was located to the east of Bo'ness near Grangepans. No-one was available for interview but about a dozen boats were seen in the water at the club and more were seen in a compound on land. No evidence of any fishing boats was seen.

Bo'ness inner and outer harbours were disused and were muddy at low tide when the substrate was exposed. No activities were seen taking place either in the harbours or on the nearby beaches, which comprised mud and stone.

4.2 Commercial fisheries

Commercial fishing was very sparse in the survey area, particularly for salmon and marine fish species, because of seriously depleted fish stocks during recent years. The main commercial fishing in the survey area was creeling for lobsters and crabs. Three fishermen who were based at Kincardine carried out a small amount of stow-netting for marine fish and shrimps. One remaining licensed salmon fisherman also kept his boat at Kincardine.

Crustaceans

Four commercial lobster/crab fishermen regularly creeled in the survey area. They were based at Burntisland, Rosyth, Newhaven and North Queensferry. They worked throughout the

year when the weather was favourable. Occasionally, the fisherman based at Burntisland Docks also fished for Norway prawns (*Nephrops norvegicus*) with trawl gear, but he did this further east, outside the aquatic survey area. There were also three fishermen based at Kincardine who employed stow-net fishing gear. These fishermen usually fished for brown shrimps (*Crangon crangon*) from January to the end of April before switching to marine fish species and migrating eels (*Anguilla anguilla*) for the rest of the year. Shrimp catches tended to be small and were sold locally by the fishermen to the community. The survey team was informed by the commercial fishermen that one or two unlicensed part-time/hobby fishermen sold lobsters to local hotels. The majority of the commercially caught lobsters (*Homarus gammarus*), brown crabs (*Cancer pagurus*) and velvet crabs (*Liocarcinus puber*) were sold for export to Spain either through Newhaven Fish Market or to one of four wholesalers, all five being based outside the survey area.

Marine fish

The only commercial fishing for marine fish was in the Kincardine area, by the three fishing boats moored at this location, during May through to the end of the year. Catches were generally small, with the majority of the fish caught being consumed by the families and friends of the fishermen involved. The main species caught were bass, eels and smelts (*Osmerus eperlanus*). The latter species were not consumed, but sold to freshwater anglers for pike (*Esox lucius*) bait.

Salmonids

The number of premises involved with the salmon industry has declined such that only one fisherman, based at Kincardine, continued to renew his license to use his boat for sweep-netting for salmon (*Salmo salar*) and sea trout (*Salmo trutta*). This compares to five licensed fishermen in 1999. He said that catches in recent seasons barely covered the cost of the license and the maintenance of his boat and fishing gear. He added that it was now more of a hobby than a way of earning a living. On the infrequent occasions when he had enough fish to justify driving the distance, he sold his catch through Glasgow fish market. The season extends from 1st April until 26th August.

Molluscs

No commercial fishing/collection of molluscs was noted in the survey area. The commercial creel fishermen said that they occasionally caught whelks (*Buccinum undatum*) as a by-catch.

4.3 Angling and hobby fishing

Angling was a popular sport in the survey area. Most anglers preferred to fish in the summer months when large numbers of mackerel and pollack (*Pollachius pollachius*) entered the area. These were the commonest species caught. Those anglers who fished throughout the year also caught some codling during the colder months. The most popular locations noted during the survey were Burntisland breakwater, North Queensferry and Granton pier. Several unlicensed fishermen set creels for catching crabs and lobsters for their households, relatives and friends consumption. However, the survey team were informed by the commercial fishermen that some crab and lobster did get sold to hotels in the survey area.

4.4 Seafood wholesalers and retailers

Four wholesalers bought most of the crustacean and whelk by-catch catch from the commercial fishermen working in the Rosyth aquatic area. These were I. McBay (Johnshaven), Davron-Crail (Fyffe), J. Prentice (Tarbuck) and Carrie-B (Leith), all of which are located outside the survey area. Much of the catch was then exported to France and Spain. A small amount of the lobster catch was retailed through hotels in the survey area.

4.5 Wildfowling

Wildfowling was pursued over the Firth of Forth intertidal areas and three local wildfowlers were interviewed. The most favoured locations were around Torry and Blackness Bays where mud was the predominant substrate type. The commonest species shot and consumed were widgeon with smaller numbers of mallard, teal and greylag geese. No sale of wildfowl to shops or hotels was noted.

4.6 Internal exposure

Adult consumption rates

Consumption rate data for adults for fish, crustaceans, molluscs, wildfowl and marine plants are shown in Tables 2 to 6 and are summarised in Table 9. The main consumers of seafood from the Rosyth survey area were the commercial fishermen and anglers together with their families.

The main species of fish (by weight) consumed by adults were mackerel and pollack. A critical group of eight individuals was identified with a maximum consumption rate of 49 kg/y and a mean of 31 kg/y. The observed 97.5 percentile rate based on 32 observations was 49 kg/y. This compares with the adult generic mean and 97.5 percentile consumption rates for fish of 15 kg/y and 40 kg/y respectively. Critical group fish consumption consisted of 51% mackerel, 39% Pollack, 9.7% cod and 0.5% flounder.

The main species of crustaceans consumed by adults were lobster and crab. A critical group of two individuals was identified with a maximum consumption rate of 36 kg/y and a mean of 28 kg/y. The observed 97.5 percentile rate based on 25 observations was 27 kg/y. This compares with the adult generic mean and 97.5 percentile consumption rates for crustaceans of 3.5 kg/y and 10 kg/y respectively. Critical group crustacean consumption consisted of 51% crab and 49% lobster.

The main species of molluscs consumed by adults were winkles and mussels. A critical group of two individuals was identified with a maximum consumption rate of 17 kg/y and a mean of 14 kg/y. The observed 97.5 percentile rate based on four observations was 16 kg/y. This compares with the adult generic mean and 97.5 percentile consumption rates for molluscs of 3.5 kg/y and 10 kg/y respectively. Critical group mollusc consumption consisted of 78% winkles and 22% mussels.

The main species of wildfowl consumed by adults were widgeon, mallard, teal and greylag geese. A critical group of two individuals was identified with a maximum consumption rate of 13 kg/y and a mean of 11 kg/y. The observed 97.5 percentile rate based on six observations was 13 kg/y. No generic consumption rates for wildfowl have been determined. Critical group wildfowl consumption consisted of 70% ducks 30% geese.

Two people interviewed during the survey consumed the marine plant samphire from Blackness Bay. Both consumed 0.11 kg/y. No generic consumption rates for marine plants have been determined.

Children's consumption rates

Consumption rate data for children for fish and wildfowl are shown in Tables 7 and 8 respectively and are summarised in Tables 10. Only children in the 15 year old age group consumed foods from these groups. No child consumers of crustaceans, molluscs or marine plants were identified.

15 year old age group

For fish, only two individuals were identified, both consuming 6.9 kg/y and these comprise the critical group. This consumption rate compares with the generic mean and 97.5 percentile

consumption rates for fish of 6.5 kg/y and 20 kg/y respectively. Critical group fish consumption consisted completely of mackerel.

For wildfowl, only two individuals were identified, both consuming 2.6 kg/y and these comprise the critical group. No generic consumption rates have been derived for this age group for wildfowl. Critical group wildfowl consumption consisted of 65% geese and 35% ducks.

The use of seaweed as a fertiliser

The survey investigated the use of seaweed as a fertiliser and soil conditioner and no such use was identified.

4.7 External exposure

Intertidal occupancy

External exposure from artificial radiation to members of the public who frequent intertidal areas depends on the occupancy rate and dose rate after subtraction of an appropriate value for natural background radiation. Dose rates over mud can be higher than those over coarser substrates due to fine grain size and consequent ability to adsorb more radioactivity. Consequently, occupancy times over mud are considered to be radiologically more important than similar times over other substrates. Estimates of natural backgrounds used by Cefas for assessing doses to individuals are 0.05 $\mu\text{Gy/h}$ for sandy substrates, 0.07 $\mu\text{Gy/h}$ for mud and 0.06 $\mu\text{Gy/h}$ for all other substrates (EA, EHS, FSA and SEPA, 2005).

The predominant intertidal substrate types in the survey area were mud, mud and sand and sand and stones. Occupancy over rock was also noted. In addition, people carried out maintenance aboard boats, whilst the boats were aground on intertidal mud.

Intertidal activities observed during the survey included salmon fishing (including gear handling), angling, bait digging, boat maintenance, wildfowling, coast guard duties, walking, mollusc collecting, beach cleaning and family groups spending time by the shore. Gamma dose rate measurements were taken at selected locations, shown in Table 37, to supplement those of SEPA's routine monitoring programme.

Table 35 lists the intertidal occupancy rates observed, grouped by substrate. A commercial salmon netsmen formed the critical group for occupancy over mud, who had a rate of 420 h/y. Coastguards and bait diggers and formed the critical group for occupancy over mud and sand, with a mean rate of 290 h/y for 33 individuals and a maximum rate of 310 h/y. A shellfish collector formed the critical group for occupancy over rock spending 84 h/y over this substrate type. Two dog walkers formed the critical group for occupancy over sand and stones, with a mean rate of 730 h/y and a maximum rate of 1100 h/y. Three individuals maintaining or living on their boats aground on mud and thus not in direct contact with the mud, had a mean critical group rate of 270 h/y and a maximum rate of 620 h/y.

Handling

Handling sediment while bait digging or mollusc collecting, or handling commercial fishing gear containing engrained sediment can give rise to skin exposure from beta radiation. This needs consideration even though the annual dose limit for skin is a factor of 50 times higher than that for effective dose. There is also a contribution to effective dose due to skin exposure (ICRP, 1991).

Table 36 shows the observations made during this survey for times spent handling sediment and commercial fishing gear.

A mean critical group sediment handling rate of 66 h/y was identified for 20 individuals, who were bait diggers, a mollusc collector and wildfowlers, with a maximum rate of 130 h/y. A

mean critical group fishing gear handling rate of 670 h/y was identified for eight fishermen, with a maximum rate of 1200 h/y.

4.8 Water based activities

Activities taking place in or on the water can lead to ingestion of water and/or inhalation of spray. These pathways are generally considered to be minor in comparison with other exposure pathways such as the ingestion of foods produced in the vicinity of a nuclear site. However, in order to allow for their assessment, relevant data have been collected.

These data provide quantitative data that might be of use in the probabilistic assessment of dose and/or risk to individuals via radiological pathways. Pathways to consider include individuals who may inhale re-suspended radioactivity in sea spray, inadvertently ingest contaminated seawater and/or have contact with and/or inadvertently ingest contaminated sediments while undertaking coastal area activities such as angling, sailing and diving.

Occupancy rates for activities taking place in or on seawater around Rosyth are shown in Table 38.

Activities in the water

Activity in the water around Rosyth was mainly by sport divers. Maximum rates of 50 h/y were obtained for five diving instructors based at Burntisland.

Activities on the water

Activity on the water was mainly by a boat dweller, commercial and hobby fishermen and people engaged on boat related work and maintenance. The boat dweller at Port Edgar had an annual occupancy afloat of 7000 hours.

5. TERRESTRIAL RADIATION PATHWAYS

5.1 Terrestrial survey area and local produce

The terrestrial survey area is shown in Figure 2. The survey area was split into two by the Firth of Forth. On the north side, farming was predominantly arable with a small amount of beef cattle. Five working farms were identified in this area to the north of the Firth of Forth. One of the five farmers farmed most of the land to the north and west of the Rosyth site, which he had rented and contracted from other land owners. On the south side of the Firth of Forth, two farms, an estate and one tenant farm were identified which produced sheep, cattle and arable crops. The estate also produced pheasants, rabbit and deer.

Crops grown in the survey area were potatoes, broccoli, oil seed rape, beans, barley, wheat and oats. These were sold to merchants and supermarkets outside the survey area. A small amount of potatoes was sold to local customers from one farm (Walkmill Farm). Cattle and lambs were sold to the Stirling auction about 40 km from Rosyth; lamb was also sold to a wholesaler in England and to an abattoir outside the area but in Scotland. Deer, pheasants and rabbits were sold to a game dealer outside the survey area. Farmers and their families were consuming potatoes, broccoli, beef, lamb, pheasant and pigeon from their own farmland.

There were three allotment sites in the survey area, two in Rosyth and one in Dunfermline. Their locations are shown in Figure 2. One of the Rosyth allotment sites was popular and regularly used. The allotment holders grew a large variety of vegetables and fruit, which were consumed by the allotment holders' households, family and friends. The second allotment site in Rosyth and the allotment site in Dunfermline had many worked plots, however no one was observed at these sites during the survey. A few private households in the survey area grew small amounts of vegetables in their gardens. One individual had chickens in their garden for the production of eggs, which were sold from the door to local customers.

One beekeeper in the survey area near Inverkeithing was identified. He had 20 hives, each producing approximately 15 kg of honey per year. The honey was sold throughout Scotland and was also consumed by the beekeeper and his family.

The consumption of wild foods from within the survey area by individuals was limited to small amounts of blackberries, raspberries and mushrooms. Pheasant, rabbit and deer were shot during organised, private shoots at the estate on the south side of the survey area. The consumption of pheasant, rabbit, venison and pigeon from the estate was identified. No evidence was obtained suggesting that the rabbits on the Rosyth Business Park entered the human food chain.

The consumption of freshwater fish was not identified in the survey area.

No households were noted to use spring or groundwater for domestic consumption and no farms were noted to use any for watering livestock.

5.2 Novel radiation pathways

The survey team spent time investigating unusual pathways such as peat cutting and consumption of unusual food types. No novel pathways were identified.

5.3 Land cover

Figure 3 shows the soil types and their capabilities for land in the survey area. The figure is reproduced from a land cover map produced by Macaulay Institute for Soil Research, Aberdeen (MISR, 1988), with their consent.

Farming practices can usually be anticipated by examining the soil type's capabilities in most areas. The majority of the land in the terrestrial survey area was classified as either Class 2 or Class 3₁. Class 2 soil is capable of producing a wide range of crops with high yield. The land may be unsuited to winter harvested crops. Class 3₁ soil is capable of producing good yields of a narrow range of cereal crops or moderate yields of a wider range of crops, including some vegetable crops, potatoes and oil seed rape.

5.4 Internal exposure

Adult consumption rates

Consumption rate data for adults are shown in Tables 12 to 25 and are summarised in Table 9. Consumption of terrestrial foods in the following 14 food groups was identified: green vegetables, other vegetables, root vegetables, potato, domestic fruit, cattle meat, sheep meat, poultry, eggs, wild/free foods, rabbits/hares, honey, wild fungi, and venison. The percentage contribution each species makes to its terrestrial food group (where they have multiple species) is shown for adults in Table 34. No consumption of locally produced milk, pig meat, freshwater fish or cereal crops was identified.

Two critical group mean consumption rates exceeded the generic 97.5 percentile consumption rates; these were for root vegetables and honey. A further two critical group mean consumption rates exceeded the generic mean consumption rates; these were for green vegetables and potato. Nine critical group mean consumption rates were less than the generic mean consumption rates; these were for other vegetables, domestic fruit, cattle meat, sheep meat, poultry, eggs, wild/free foods, rabbits/hares and wild fungi. The observed 97.5 percentile consumption rates for root vegetables, potatoes and honey exceeded the generic 97.5 percentile consumption rates. There are currently no generic consumption data available for venison.

Children's consumption rates

Consumption rate data for children are shown in Tables 26 to 33 and are summarised in Tables 10 and 11 for the 15 year old and 5 year old age groups respectively. No children in the 10 year, 1 year or 3 month old age groups were identified as consuming locally produced terrestrial foods.

15 year old age group

Consumption of locally produced terrestrial foods was identified in the following seven food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, wild/free foods and venison. No consumption was identified for the following food groups: milk, cattle meat, pig meat, sheep meat, poultry, eggs, rabbits/hares, honey, wild fungi and freshwater fish. No critical group mean consumption rates exceeded the generic 97.5 percentile consumption rates. Two critical group mean consumption rates exceeded the generic mean consumption rates; these were for green vegetables and root vegetables. Four critical group mean consumption rates were less than the generic mean consumption rates; these were for other vegetables, potato, domestic fruit and wild/free foods. No observed 97.5 percentile consumption rates exceeded the generic 97.5 percentile consumption rates. There are currently no generic consumption data available for venison.

5 year old age group

Consumption of locally produced terrestrial foods was identified only for sheep meat. No consumption was identified for the following food groups: green vegetables, other vegetables, root vegetables, potato, domestic fruit, milk, cattle meat, pig meat, poultry, eggs, wild/free foods, rabbits/hares, honey, wild fungi, venison and freshwater fish. No generic consumption rates have been determined for this age group.

6. DIRECT RADIATION

The direct radiation survey sought information on the amount of time spent indoors and outdoors in hours per year by people living and/or working and/or pursuing leisure activities within 1 km of the site centre (Figure 2). These data are presented in Table 39 and associated gamma dose rates are given in Table 40. Occupancy due to employment associated with nuclear licensed operations at Rosyth was not considered. Occupants of residences and businesses located within the direct radiation survey area were interviewed about their times at home and at their place of business, both inside and outside. Gamma dose rate measurements were taken inside and outside a representative selection of these properties. For comparison, background readings were taken from outside the 5 km survey area.

Direct radiation survey area

Rosyth Business Park is situated 3 km south of Dunfermline on the north shore of the Firth of Forth. The direct radiation survey area was a mix of agricultural land, domestic areas and industrial areas which included the ferry operations staff, customs staff and the coal terminal staff. Housing areas were concentrated adjacent to the northern perimeter of Rosyth Business Park. The housing was a mixture of naval, local authority and private accommodation. Private businesses were present immediately to the north and east of the site in rented properties owned by Rosyth Business Park, but off the actual Naval base. Few leisure activities were observed within the survey area, other than local residents walking and dog walking in the domestic areas of the survey areas.

Occupancy within direct radiation survey area

Local residents, employees and visitors to the survey area were interviewed and their occupancy rates within the direct radiation survey area were recorded (Table 39). Two individuals had occupancy rates over 8000 h/y, both were residents living in Dundonald Road,

with the highest rate being 8400 h/y. Eleven other residents had occupancy rates over 7000 h/y, two of whom were children aged 4 and 1.

Gamma dose rate measurements

Gamma dose rate measurements were taken at a height of 1m above the ground at some residences and businesses in the survey area. Measurements were taken both inside and outside the properties, with the outdoor measurements being taken over grass in gardens, approximately 5-10 metres from the nearest building. Measurements were also taken over grass at locations remote from the survey area to obtain comparison background dose rates (Table 40). The outside measurements in gardens at the residences were generally higher than the background measurements, also taken over grass. All but 1 of the measurements taken inside the residences were significantly higher than the corresponding outdoor measurements. Cefas experience has shown that indoor measurements are usually higher than outdoor measurements but that this is attributable to natural radiation emanating from the building materials of the properties.

The maximum gamma dose rates measured in the direct radiation survey area were 0.096 $\mu\text{Gy/h}$ outside a residence and 0.118 $\mu\text{Gy/h}$ inside a residence. These dose rate measurements compare to the mean of the background measurements taken over grass of 0.067 $\mu\text{Gy/h}$.

7. COMBINED PATHWAYS

In determining habits data for the purposes of assessing radiological doses to the public, it may be necessary to consider a combination of pathways. Data are provided in Annexes 1 and 2 so that the full effect of combining pathways can be assessed for individual observations, given the concentrations and dose rates for a particular assessment. In some circumstances it will be possible to make simplifying assumptions, and define the consumption and external exposure rates appropriate to a series of potential critical groups. Such assumptions will depend on the assessment in question but some initial observations are provided here as a starting point for those undertaking assessments.

The most extensive combinations of pathways for adult dose assessment are shown in Annex 3. Each of the twenty combinations shown in this annex represents an actual individual (or individuals) from Annex 1 who has positive data (irrespective of the magnitude), for each pathway marked with an asterisk. It should be noted that combination numbers in Annex 3 do not correlate directly with observation numbers in Annex 1. Other individuals from Annex 1 have combinations that are not listed in Annex 3 because they have fewer pathways and a dose assessment for them would be adequately covered by one of the twenty listed combinations.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Survey findings

Exposure pathways were investigated for 1229 individuals (1194 adults and 35 children). The survey considered pathways relating to three potential sources of exposure:

- Discharges of liquid radioactive waste to the Firth of Forth
- Discharges of gaseous radioactive waste to the atmosphere
- Direct radiation emitted directly from the site

The adult critical group mean consumption rates of aquatic foods were:

- 31 kg/y for fish
- 28 kg/y for crustaceans
- 14 kg/y for molluscs
- 11 kg/y for wildfowl
- 0.11 kg/y for marine plants

For the critical groups, the main fish species consumed were mackerel, pollack and cod, the only crustacean species consumed were crabs and lobsters, the only molluscan species consumed were winkles and mussels, the wildfowl consumed were duck and geese and the marine plant consumed was samphire.

The critical group mean occupancy rates over intertidal areas were:

- 84 h/y for rock
- 290 h/y for mud and sand
- 420 h/y for mud
- 730 h/y for sand and stone
- 279 h/y for boat occupancy over mud

The critical group mean handling rates for fishing gear and sediment were 670 h/y and 66 h/y respectively.

The adult critical group mean consumption rates of terrestrial foods were:

- 19 kg/y for green vegetables
- 18 kg/y for other vegetables (see Table 1)
- 100 kg/y for root vegetables
- 86 kg/y for potato
- 13 kg/y for domestic fruit
- 2.5 kg/y for cattle meat
- 3.9 kg/y for sheep meat
- 1.4 kg/y for poultry
- 6.9 kg/y for eggs
- 1.8 kg/y for wild/free foods
- 0.45 kg/y for rabbits and hares
- 12 kg/y for honey
- 0.30 kg/y for wild fungi
- 0.60 kg/y for venison

The main terrestrial foods consumed were green vegetables, root vegetables, other vegetables, potato, domestic fruit, eggs and honey. The percentage contribution each terrestrial food type made to its food group for adults is shown in Table 34.

For occupancy of members of the public within 1 km of the site centre, the highest rate (indoor plus outdoor) was 8400 h/y.

8.2 Comparisons with previous surveys

This section compares the results of the 1999 survey with those of this survey. For direct radiation and terrestrial foods the survey areas were the same. The aquatic area was increased slightly as explained in Section 2.3 to include fishing activities taking place at Kincardine and Kinghorn.

The critical group mean consumption rates in 2005 for fish and shellfish groups have increased significantly when compared to the adult critical group mean consumption rates obtained from the 1999 survey. In 1999, these were 21 kg/y for fish, 6.6 kg/y for crustaceans and 5.6 kg/y for molluscs, compared to the 2005 survey's consumption rates of 31 kg/y for fish, 28 kg/y for crustaceans and 14 kg/y for molluscs. Fish species were similar with the exception of pollack which were consumed this survey and not in 1999 and there was no consumption of eels this survey which was a consumed species during the 1999 survey. Crustacean species were lobsters, crabs and shrimps this survey and in 1999 *Nephrops* were consumed in addition to these three species. Molluscs consumed both surveys were winkles, mussels and whelks. The former two species in larger amounts in 2005 and the latter species in smaller amounts in 2005. The adult critical group mean consumption rates for wildfowl and

marine plants in 2005 were 11 and 0.11 kg/y respectively. These food groups were not noted as being consumed in the 1999 survey.

For external pathways, it should be noted that the methodology for determining the critical group has changed since the 1999 survey (described in Section 3.2) so care is needed when comparing results.

The 1999 survey identified occupancy over mud and a mixture of mud and sand, whereas the 2005 survey additionally identified occupancy over sand and stones, rock and occupancy on board boats aground over harbour mud. The 1999 survey identified a critical group mean intertidal occupancy rate over mud and sand of 1100 h/y (850 h/y using the current methodology). In this report several substrate types have been considered and critical group mean occupancy rates of 84 h/y over rock, 290 h/y over mud and sand, 420 h/y over mud, 730 h/y over sand and stones and 270 h/y on boats aground over mud were identified.

The 1999 survey critical group mean fishing gear handling rate was 1300 h/y (also 1300 h/y using the current methodology), compared to the 2005 survey's rate of 670 h/y and the 1999 survey critical group mean sediment handling rate was 210 h/y (also 210 h/y using the current methodology), compared to the 2005 survey's rate of 66 h/y.

For terrestrial food groups, the adult critical group consumption rates (kg/y) in the 2005 survey are tabulated below, together with those of the 1999 survey for ease of comparison:

	1999	2005
• Green vegetables	41	19
• Other vegetables	15	18
• Root vegetables	29	100
• Potato	94	86
• Domestic fruit	16	13
• Milk	Nil	Nil
• Cattle meat	Nil	2.5
• Pig meat	Nil	Nil
• Sheep meat	Nil	3.9
• Poultry	32	1.4
• Eggs	Nil	6.9
• Wild/free foods	2.3	1.8
• Rabbits/hares	29	0.45
• Honey	0.40	12
• Wild fungi	2.3	0.30
• Venison	2.5	0.60
• Freshwater fish	3.2	Nil

Consumption rates have increased in the following food groups: other vegetables, root vegetables, cattle meat, sheep meat, eggs and honey. Consumption rates had decreased in the following food groups: green vegetables, potato, domestic fruit, poultry, wild/free foods, rabbits/hares, wild fungi, venison and freshwater fish.

The most significant increases were for root vegetables and honey. The most significant decreases in consumption rates were noted for green vegetables, poultry and rabbits/hares. Consumption of cattle meat, sheep meat and eggs was identified which had not been the case during the 1999 survey. A food group consumed in 1999 and not identified as being consumed in 2005 was freshwater fish (brown trout). Milk and pig meat were not identified as being consumed in either survey.

In common with the 1999 direct radiation survey, this survey identified several individuals living in the Rosyth area who spent significant times within 1 km of the site.

8.3 Recommendations for environmental monitoring

One important objective of habits surveys is to recommend or suggest changes or additions to the environmental monitoring programme.

The 2004 aquatic monitoring programme carried out on behalf of SEPA comprised sampling of sediments from Blackness Castle, Burntisland Bay, east and west of the dockyard and Port Edgar and *Fucus vesiculosus* and crabs from east of the dockyard. In addition, gamma dose rates, at the same locations that the sediment samples were taken, were measured.

No monitoring of terrestrial pathways was carried out.

SEPA's current monitoring programme provides adequate coverage for the aquatic environment. However, the habits survey has identified the following aquatic and terrestrial samples that could be considered for adding to the programme:

Aquatic

- a biannual winkle sample from St Davids harbour area as they were consumed by the critical group
- a biannual mussel sample from Aberdour Bay as they were consumed by the critical group
- a biannual shrimp sample from Kincardine as they were consumed by the critical group
- a biannual lobster sample from east of dockyard as they were consumed by the critical group
- a biannual gamma dose rate measurement over mud and a mud sample in the St Davids Bay area (suggested NGR NT 144 825)
- a biannual gamma dose rate measurement over mud and a mud sample at Kincardine slipway (NGR NT 927 873)

Terrestrial

- an annual honey sample from nearest beekeeper to site (Mr M. Taddie at Aberdour)
- an annual wild blackberry sample available from the nearest farm land or hedge rows where bushes occur (at the time of the survey the Rosyth site had blackberry bushes growing on an area of unused land which may yield sufficient for a sample)
- an annual runner bean sample from the allotments on Admiralty/Kings Road, Rosyth
- an annual cabbage sample from the allotments on Admiralty/Kings Road, Rosyth

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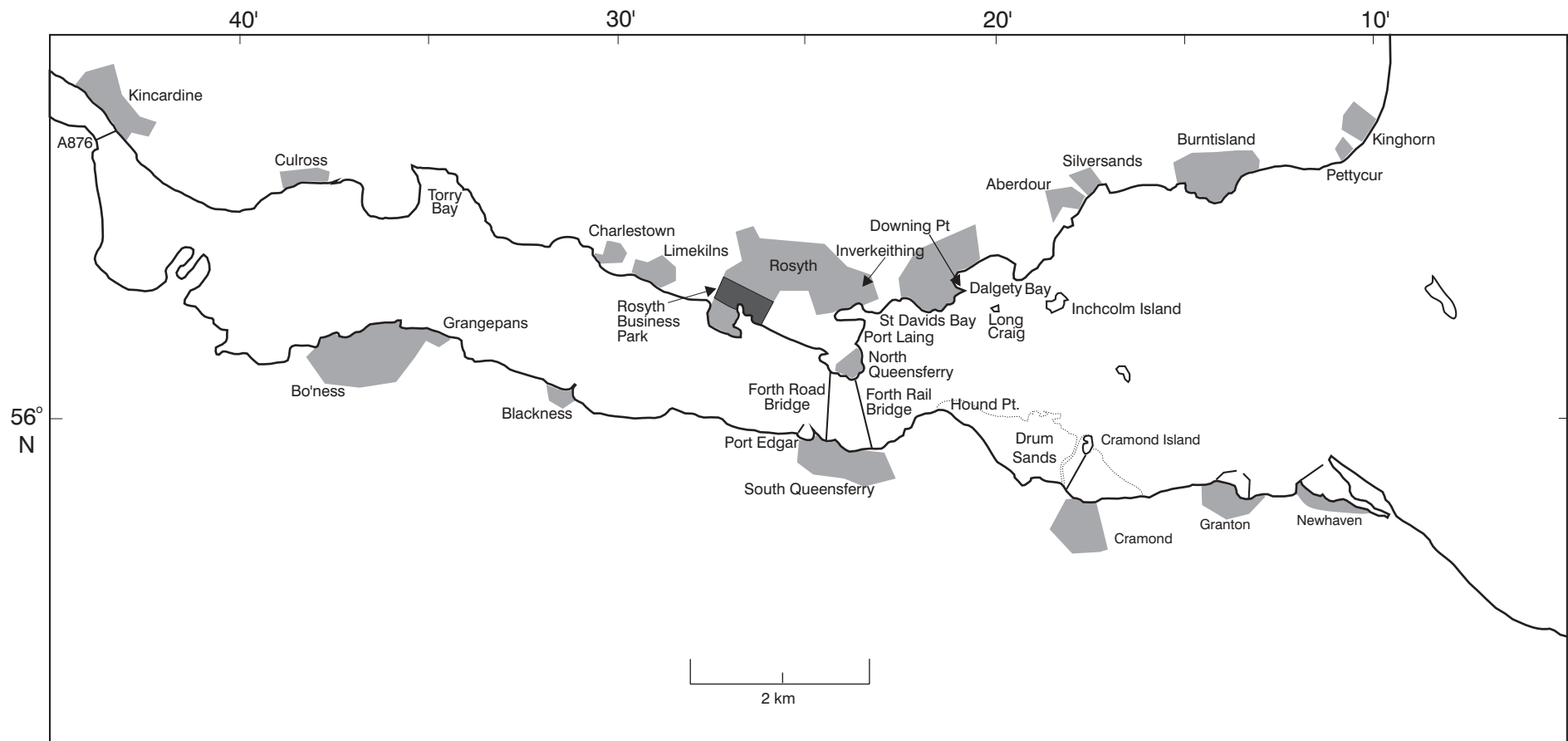


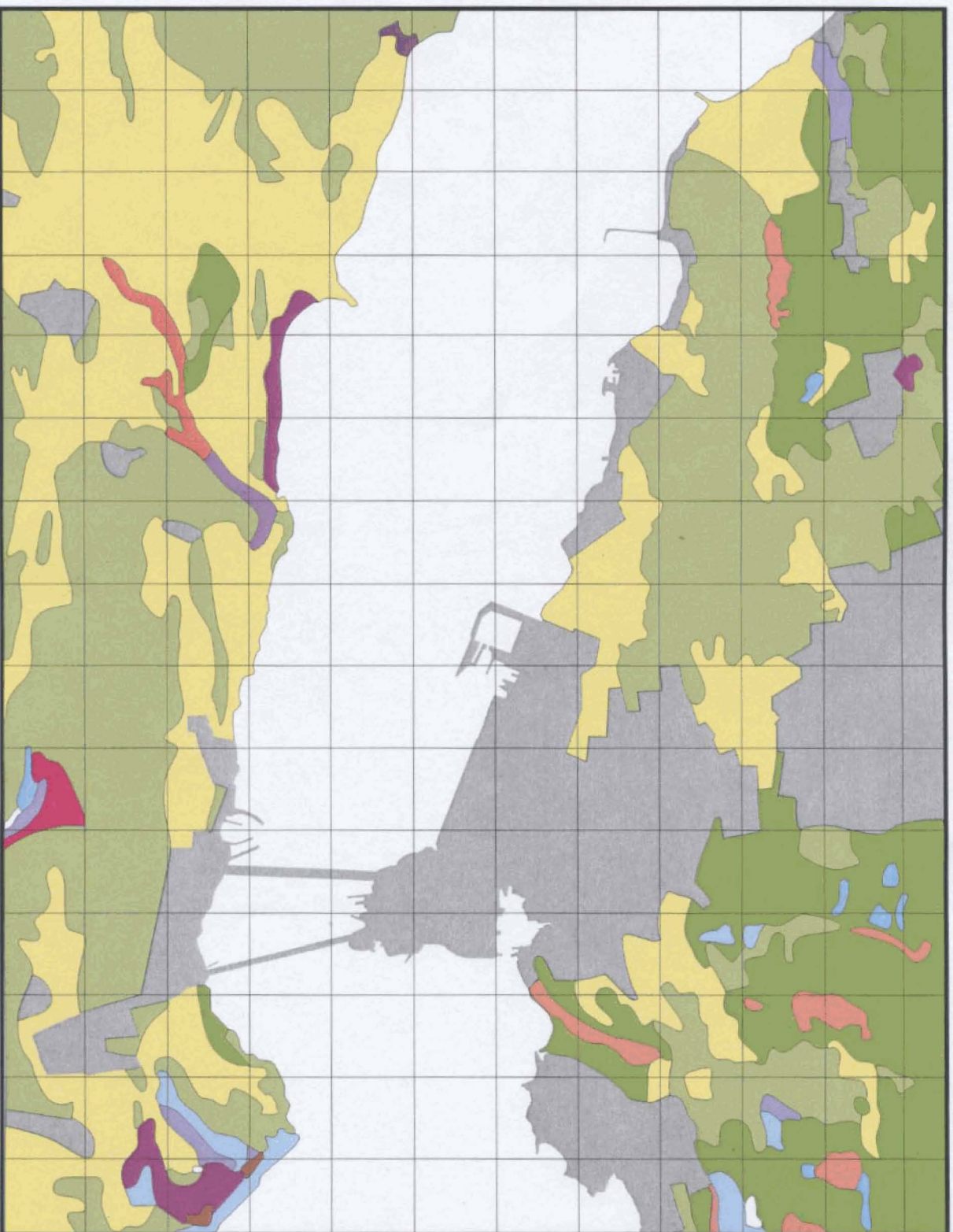
Figure 1. The Rosyth aquatic survey area.



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Figure 2. The Rosyth terrestrial (outer ring) and direct radiation (inner ring) survey areas.

- 1 Dumfermline allotments
- 2 Wemyss Road allotments
- 3 Admiralty Road allotments



Class Capability

- 1** Very wide range of crops
- 2** Wide range of crops
- 31** Moderate ranges of crops
- 32** Moderate ranges of crops
- 41** Narrow range of crops
- 42** Narrow range of crops
- 51** Use as improved grassland
- 52** Use as improved grassland
- 61** Use as rough grazing
- 62** Use as rough grazing
- 7** Very limited agriculture value

1km

Figure 3. Soil types around the Rosyth Business Park

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Base scale is 1:50000

Table 1. Typical food groups used in habits surveys

Green vegetables	Globe artichoke, asparagus, broccoli, brussel sprout, cabbage, calabrese, cauliflower, chard, courgettes, cucumber, gherkin, herbs, kale, leaf beet, lettuce, marrow, spinach
Other vegetables	Aubergine, broad bean, chilli pepper, french bean, mangetout, pea, pepper, runner bean, sweetcorn, tomato
Root vegetables	Jerusalem artichoke, beetroot, carrot, celeriac, celery, chicory, fennel, garlic, kohlrabi, leek, onion, parsnip, radish, shallot, spring onion, swede, turnip
Potato	
Domestic fruit	Apple, apricot, blackberry, blackcurrant, boysenberry, cherry, damson, fig, gooseberry, grapes, greengages, huckleberry, loganberry, melon, nectarines, peach, pear, plum, pumpkin, raspberry, redcurrants, rhubarb, rowanberry, strawberry, tayberry, whitecurrant
Milk	Milk, butter, cream, cheese, yoghurt, goats milk
Cattle meat †	
Pig meat †	
Sheep meat †	
Poultry	Chicken, duck, goose, grouse, guinea fowl, partridge, pheasant, pigeon, snipe, turkey, woodcock
Eggs	Chicken egg, duck egg, goose egg
Wild/free foods	Blackberry, blackcurrant, chestnut, crab apple, damson, dandelion root, elderberry, nettle, raspberry, rowanberry, samphire, sloe, strawberry, watercress, wild apple
Honey	
Wild Fungi	Mushrooms
Rabbits/Hare	Hare, rabbit
Venison †	
Fish (sea)	Bass, brill, cod, common ling, dab, Dover sole, flounder, gurnard, haddock, hake, herring, lemon sole, mackerel, monkfish, mullet, plaice, pollack, witch saithe, salmon, sea trout, squid*, cuttlefish*, rays, turbot, whitebait, whiting
Freshwater fish	Brown trout, rainbow trout, perch, pike, salmon (river), eels
Crustaceans	Brown crab, spider crab, crawfish, lobster, <i>Nephrops</i> , squat lobster, prawn, shrimp
Molluscs	Cockles, limpets, mussels, oysters, queen scallop, razor shell, whelks, winkles

Notes:

* Although squid and cuttlefish are molluscs, radiologically they are more akin to fish

† Including offal

Table 2. Adults' consumption rates of fish in the Rosyth area (kg/y)

Observation number	Bass	Cod	Flounder	Mackerel	Pollack	Salmon	Total
170-171				16.7	32.2		48.9
1224				37.6			37.6
1226		6.0		18.8			24.8
172-173				8.3	16.1		24.4
174		18.0	1.2	2.7			21.9
1221				16.6			16.6
1227		6.0		9.4			15.4
1113-1114				12.5			12.5
1115-1117		2.0		9.2			11.2
1220				11.1			11.1
1222-1223				11.1			11.1
761				9.2			9.2
1108		9.0					9.0
1099		7.5					7.5
1109-1110				6.9			6.9
1072-1073						6.5	6.5
644		3.3		3.2			6.5
646		3.3		3.2			6.5
1070	4.0						4.0
1071	1.3					1.6	2.9
1074-1076	1.3					1.6	2.9
1097			1.8				1.8

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of fish based on the 8 highest adult consumers is 31.0 kg/y

The observed 97.5 percentile rate based on 32 observations is 48.9 kg/y

Table 3. Adults' consumption rates of crustaceans in the Rosyth area (kg/y)

Observation number	Brown shrimp	Crab	Lobster	Total
1103		17.2	18.6	35.8
1227		11.7	9.1	20.8
1104-1107			6.2	6.2
1069		2.0	3.5	5.5
1064-1068		1.7	2.0	3.8
306		0.8	1.3	2.1
1226		0.8	1.3	2.1
1070-1071	2.0			2.0
1100-1102			2.0	2.0
304		1.2	0.4	1.7
174			1.3	1.3
1225			1.3	1.3
303		1.2		1.2
305		1.2		1.2
307		0.8		0.8

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of crustaceans based on the 2 highest adult consumers is 28.3 kg/y

The observed 97.5 percentile rate based on 25 observations is 26.8 kg/y

Table 4. Adults' consumption rates of molluscs in the Rosyth area (kg/y)

Observation number	Mussel	Whelk	Winkle	Total
1097	6.0		10.7	16.7
1098			10.7	10.7
303		0.5		0.5
305		0.5		0.5

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of molluscs based on the 2 highest adult consumers is 13.7 kg/y

The observed 97.5 percentile rate based on 4 observations is 16.3 kg/y

Table 5. Adults' consumption rates of wildfowl in the Rosyth area (kg/y)

Observation number	Goose	Mallard	Teal	Wigeon	Total
348		8.1	3.2	2.1	13.4
176	6.6	1.4		0.7	8.7
349	1.7	2.7			4.4
350	1.7	0.9			2.6
13				1.3	1.3
14				1.3	1.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of wildfowl based on the 2 highest adult consumers is 11.0 kg/y

The observed 97.5 percentile rate based on 6 observations is 12.8 kg/y

Table 6. Adults' consumption rates of marine plants in the Rosyth area (kg/y)

Observation number	Samphire
13	0.1
14	0.1

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of marine plants based on the 2 highest adult consumers is 0.1 kg/y

The observed 97.5 percentile rate based on 2 observations is 0.1 kg/y

Table 7. Children's consumption rates of fish in the Rosyth area (kg/y)

15 year old age group

Observation number	Age	Mackerel
1112	16	6.9
1111	14	6.9

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of fish based on the 2 highest 15 year old age group consumers is 6.9 kg/y

The observed 97.5 percentile rate based on 2 observations is 6.9 kg/y

Table 8. Children's consumption rates of wildfowl in the Rosyth area (kg/y)

15 year old age group

Observation number	Age	Duck	Goose	Total
351	14	0.9	1.7	2.6
352	13	0.9	1.7	2.6

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of wildfowl based on the 2 highest 15 year old age group consumers is 2.6 kg/y

The observed 97.5 percentile rate based on 2 observations is 2.6 kg/y

Table 9. Summary of adults' consumption rates in the Rosyth area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical consumption rate	Observed minimum critical consumption rate	Observed critical group mean consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	32	8	48.9	16.6	31.0	48.9	15.0	40.0
Crustaceans	25	2	35.8	20.8	28.3	26.8	3.5	10.0
Molluscs	4	2	16.7	10.7	13.7	16.3	3.5	10.0
Marine plants	2	2	0.1	0.1	0.1	0.1	ND	ND
Wildfowl	6	2	13.4	8.7	11.0	12.8	ND	ND
Green vegetables	53	11	30.2	13.1	18.7	27.1	15.0	45.0
Other vegetables	38	6	27.2	12.2	17.6	27.2	20.0	50.0
Root vegetables	47	2	102.2	102.2	102.2	90.3	10.0	40.0
Potato	49	17	144.0	54.6	85.5	144.0	50.0	120.0
Domestic fruit	27	4	19.0	7.1	13.0	19.0	20.0	75.0
Milk	NC	NC	NC	NC	NC	NC	95.0	240.0
Cattle meat	4	4	2.5	2.5	2.5	2.5	15.0	45.0
Pig meat	NC	NC	NC	NC	NC	NC	15.0	40.0
Sheep meat	10	10	3.9	3.9	3.9	3.9	8.0	25.0
Poultry	9	2	1.8	1.1	1.4	1.7	10.0	30.0
Eggs	3	3	6.9	6.9	6.9	6.9	8.5	25.0
Wild/free foods	5	1	1.8	1.8	1.8	1.7	7.0	25.0
Rabbits/hares	2	2	0.5	0.5	0.5	0.5	6.0	15.0
Honey	3	3	11.8	11.8	11.8	11.8	2.5	9.5
Wild fungi	3	3	0.3	0.3	0.3	0.3	3.0	10.0
Venison	4	4	0.6	0.6	0.6	0.6	ND	ND
Fish (freshwater)	NC	NC	NC	NC	NC	NC	15.0	40.0

ND = not determined

NC = not consumed

Table 10. Summary of 15 year old children's consumption rates in the Rosyth area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical consumption rate	Observed minimum critical consumption rate	Observed critical group mean consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	2	2	6.9	6.9	6.9	6.9	6.5	20.0
Crustaceans	NC	NC	NC	NC	NC	NC	2.5	6.0
Molluscs	NC	NC	NC	NC	NC	NC	2.5	6.0
Wildfowl	2	2	2.6	2.6	2.6	2.6	ND	ND
Green vegetables	3	2	13.2	7.5	10.3	12.9	9.0	25.0
Other vegetables	2	1	8.1	8.1	8.1	7.9	10.0	30.0
Root vegetables	2	2	15.7	5.4	10.5	15.4	7.5	20.0
Potato	2	2	36.4	32.8	34.6	36.3	60.0	130.0
Domestic fruit	1	1	5.0	5.0	5.0	NA	15.0	50.0
Milk	NC	NC	NC	NC	NC	NC	110.0	260.0
Cattle meat	NC	NC	NC	NC	NC	NC	15.0	35.0
Pig meat	NC	NC	NC	NC	NC	NC	10.0	30.0
Sheep meat	NC	NC	NC	NC	NC	NC	5.5	15.0
Poultry	NC	NC	NC	NC	NC	NC	6.5	20.0
Eggs	NC	NC	NC	NC	NC	NC	7.0	25.0
Wild/free foods	1	1	0.2	0.2	0.2	NA	3.0	13.0
Rabbits/hares	NC	NC	NC	NC	NC	NC	ND	ND
Honey	NC	NC	NC	NC	NC	NC	2.0	5.0
Wild fungi	NC	NC	NC	NC	NC	NC	2.0	5.5
Venison	1	1	0.6	0.6	0.6	NA	ND	ND
Fish (freshwater)	NC	NC	NC	NC	NC	NC	6.5	20.0

ND = not determined
 NC = not consumed
 NA = not applicable

Table 11. Summary of 5 year old children's consumption rates in the Rosyth area (kg/y or l/y)

Food group	Number of observations	No. higher rate consumers	Observed maximum critical consumption rate	Observed minimum critical consumption rate	Observed critical group mean consumption rate	Observed 97.5 %ile consumption rate	Generic mean consumption rate	Generic 97.5 %ile consumption rate
Fish	NC	NC	NC	NC	NC	NC	ND	ND
Crustaceans	NC	NC	NC	NC	NC	NC	ND	ND
Molluscs	NC	NC	NC	NC	NC	NC	ND	ND
Green vegetables	NC	NC	NC	NC	NC	NC	ND	ND
Other vegetables	NC	NC	NC	NC	NC	NC	ND	ND
Root vegetables	NC	NC	NC	NC	NC	NC	ND	ND
Potato	NC	NC	NC	NC	NC	NC	ND	ND
Domestic fruit	NC	NC	NC	NC	NC	NC	ND	ND
Milk	NC	NC	NC	NC	NC	NC	ND	ND
Cattle meat	NC	NC	NC	NC	NC	NC	ND	ND
Pig meat	NC	NC	NC	NC	NC	NC	ND	ND
Sheep meat	3	3	2.0	2.0	2.0	2.0	ND	ND
Poultry	NC	NC	NC	NC	NC	NC	ND	ND
Eggs	NC	NC	NC	NC	NC	NC	ND	ND
Wild/free foods	NC	NC	NC	NC	NC	NC	ND	ND
Rabbits/hares	NC	NC	NC	NC	NC	NC	ND	ND
Honey	NC	NC	NC	NC	NC	NC	ND	ND
Wild fungi	NC	NC	NC	NC	NC	NC	ND	ND
Venison	NC	NC	NC	NC	NC	NC	ND	ND
Fish (freshwater)	NC	NC	NC	NC	NC	NC	ND	ND

ND = not determined

NC = not consumed

Table 12. Adults' consumption rates of green vegetables in the Rosyth area (kg/y)

Observation number	Broccoli	Brussel sprout	Cabbage	Cauliflower	Chard	Courgettes	Lettuce	Marrow	Total
621-622			10.7	7.1				12.5	30.2
681-682	3.4		4.3		1.2	11.0			19.9
636, 638	5.2	3.2	7.5	2.6					18.5
609-610	4.5		3.7			3.7	1.8	1.1	14.7
637	3.7	2.3	5.3	1.9					13.2
603-604	11.2					1.8			13.1
640-643	2.2	1.4	3.2	1.1					7.9
647-653			5.2	1.3			1.0		7.5
605-607	7.5								7.5
644-645			1.8			4.4			6.2
617-618		1.8	2.4					0.7	5.0
1062-1063		1.8	1.7			1.2			4.7
623-624			1.5	1.0				1.8	4.3
646			1.2			2.9			4.2
634-635			4.1						4.1
683-685	1.4		1.7		0.5				3.5
611-616	1.0		0.8			0.5	0.4	0.2	2.9
619-620		0.9	1.2					0.4	2.5
601-602	2.0								2.0
596-597	0.8								0.8
599-600	0.8								0.8

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of green vegetables based on the 11 highest adult consumers is 18.7 kg/y

The observed 97.5 percentile rate based on 53 observations is 27.1 kg/y

Table 13. Adults' consumption rates of other vegetables in the Rosyth area (kg/y)

Observation number	Broad bean	French bean	Pea	Runner bean	Sweetcorn	Total
603-604			6.8	20.4		27.2
621-622		6.3		7.1		13.4
609-610	1.4		2.7	8.2		12.2
605-607		3.6	4.5			8.1
617-618			2.7	4.3	0.6	7.6
619-620			1.4	2.1	0.3	3.8
611-616	0.3		0.6	1.8		2.7
1062-1063				2.2		2.2
681-682				2.0		2.0
623-624		0.9		1.0		1.9
636, 638			1.6			1.6
637			1.1			1.1
644-645		1.1				1.1
683-685				0.8		0.8
646		0.7				0.7
640-643			0.7			0.7

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of other vegetables based on the 6 highest adult consumers is 17.6 kg/y

The observed 97.5 percentile rate based on 38 observations is 27.2 kg/y

Table 14. Adults' consumption rates of root vegetables in the Rosyth area (kg/y)

Observation number	Beetroot	Carrot	Fennel	Garlic	Kohl rabi	Leek	Onion	Parsnip	Spring onion	Swede	Turnip	Total
621-622	7.9	10.1				31.5	22.7	6.3		23.8		102.2
617-618	4.1	7.2				2.7	7.2				1.7	22.9
636	3.2	3.2				2.4	8.8		0.7		3.8	22.0
638	3.2	3.2					8.8		0.7		3.8	19.6
609-610	2.7	2.7				4.1	5.4		1.2		3.2	19.3
603-604	6.8										12.2	18.9
647-653		3.9				5.1	3.1		1.0		4.6	17.7
681-682		6.8				5.0	5.0					16.7
637	2.3	2.3				1.7	6.3		0.5		2.7	15.7
623-624	1.1	1.4				4.5	3.2	0.9		3.4		14.6
634-635	2.0					2.0	4.1				4.9	13.0
644-645	1.4	1.4	0.1	0.1	2.7	1.4	1.1		0.6	4.1		12.7
619-620	2.7	3.6				1.4	3.6				0.8	12.1
640-643	1.4	1.4				1.0	3.8		0.3		1.6	9.4
1062-1063		2.7					4.4	1.7				8.7
646	0.9	0.9	0.1	0.1	1.8	0.9	0.7		0.4	2.7		8.5
683-685		2.7				2.0	2.0					6.7
605-607											5.4	5.4
611-616	0.6	0.6				0.9	1.2		0.3		0.7	4.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of root vegetables based on the 2 highest adult consumers is 102.2 kg/y

The observed 97.5 percentile rate based on 47 observations is 90.3 kg/y

Table 15. Adults' consumption rates of potato in the Rosyth area (kg/y)

Observation number	Potato
592-595	144.0
621-622	111.5
647-649	62.4
650-653	62.4
640-643	54.6
603-604	41.0
617-618	40.0
605-607	36.4
609-610	32.8
636-638	32.8
634-635	24.6
619-620	20.0
623-624	15.9
681-682	12.7
1062-1063	10.0
611-616	7.3
683-685	5.1
646	1.8

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of potato based on the 17 highest adult consumers is 85.5 kg/y

The observed 97.5 percentile rate based on 49 observations is 144.0 kg/y

Table 16. Adults' consumption rates of domestic fruit in the Rosyth area (kg/y)

Observation number	Raspberry	Rhubarb	Strawberry	Total
621-622		2.3	16.7	19.0
636, 638		0.4	6.7	7.1
637		0.3	4.8	5.0
623-624		1.2	2.4	3.5
640-643		0.2	2.9	3.0
681-682	2.3			2.3
683-685	0.9			0.9
617-618		0.5		0.5
647-650		0.3		0.3
651-653		0.3		0.3
619-620		0.2		0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of domestic fruit based on the 4 highest adult consumers is 13.0 kg/y

The observed 97.5 percentile rate based on 27 observations is 19.0 kg/y

Table 17. Adults' consumption rates of cattle meat in the Rosyth area (kg/y)

Observation number	Beef
592-595	2.5

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of cattle meat based on the 4 highest adult consumers is 2.5 kg/y

The observed 97.5 percentile rate based on 4 observations is 2.5 kg/y

Table 18. Adults' consumption rates of sheep meat in the Rosyth area (kg/y)

Observation number	Lamb
283-292	3.9

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of sheep meat based on the 10 highest adult consumers is 3.9 kg/y

The observed 97.5 percentile rate based on 10 observations is 3.9 kg/y

Table 19. Adults' consumption rates of poultry in the Rosyth area (kg/y)

Observation number	Pheasant	Pigeon	Total
296	1.8		1.8
297	0.2	0.9	1.1
644-645	0.5		0.5
298-302	0.2		0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of poultry based on the 2 highest adult consumers is 1.4 kg/y

The observed 97.5 percentile rate based on 9 observations is 1.7 kg/y

Table 20. Adults' consumption rates of eggs in the Rosyth area (kg/y)

Observation number	Chicken egg
297, 298, 302	6.9

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of eggs based on the 3 highest adult consumers is 6.9 kg/y

The observed 97.5 percentile rate based on 3 observations is 6.9 kg/y

Table 21. Adults' consumption rates of wild/free foods in the Rosyth area (kg/y)

Observation number	Blackberry	Raspberry	Total
297		1.8	1.8
596-597	0.2		0.2
599-600	0.2		0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of wild/free foods based on the highest adult consumer is 1.8 kg/y

The observed 97.5 percentile rate based on 5 observations is 1.7 kg/y

Table 22. Adults' consumption rates of rabbits/hares in the Rosyth area (kg/y)

Observation number	Rabbit
644-645	0.5

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of rabbits/hares based on the 2 highest adult consumers is 0.5 kg/y

The observed 97.5 percentile rate based on 2 observations is 0.5 kg/y

Table 23. Adults' consumption rates of honey in the Rosyth area (kg/y)

Observation number	Honey
589-591	11.8

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of honey based on the 3 highest adult consumers is 11.8 kg/y

The observed 97.5 percentile rate based on 3 observations is 11.8 kg/y

Table 24. Adults' consumption rates of wild fungi in the Rosyth area (kg/y)

Observation number	Mushrooms
297, 298, 302	0.3

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of wild fungi based on the 3 highest adult consumers is 0.3 kg/y

The observed 97.5 percentile rate based on 3 observations is 0.3 kg/y

Table 25. Adults' consumption rates of venison in the Rosyth area (kg/y)

Observation number	Venison
596-597	0.6
599-600	0.6

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of venison based on the 4 highest adult consumers is 0.6 kg/y

The observed 97.5 percentile rate based on 4 observations is 0.6 kg/y

Table 26. Children's consumption rates of green vegetables in the Rosyth area (kg/y)**15 year old age group**

Observation number	Age	Broccoli	Brussel sprout	Cabbage	Cauliflower	Total
639	16	3.7	2.3	5.3	1.9	13.2
608	14	7.5				7.5
598	14	0.8				0.8

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of green vegetables based on the 2 highest 15 year old age group consumers is 10.3 kg/y

The observed 97.5 percentile rate based on 3 observations is 12.9 kg/y

Table 27. Children's consumption rates of other vegetables in the Rosyth area (kg/y)**15 year old age group**

Observation number	Age	French bean	Pea	Total
608	14	3.6	4.5	8.1
639	16		1.1	1.1

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of other vegetables based on the highest 15 year old age group consumers is 8.1 kg/y

The observed 97.5 percentile rate based on 2 observations is 7.9 kg/y

Table 28. Children's consumption rates of root vegetables in the Rosyth area (kg/y)**15 year old age group**

Observation number	Age	Beetroot	Carrot	Leek	Onion	Spring onion	Turnip	Total
639	16	2.3	2.3	1.7	6.3	0.5	2.7	15.7
608	14						5.4	5.4

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of root vegetables based on the 2 highest 15 year old age group consumers is 10.5 kg/y

The observed 97.5 percentile rate based on 2 observations is 15.4 kg/y

Table 29. Children's consumption rates of potato in the Rosyth area (kg/y)

15 year old age group

Observation number	Age	Potato
608	14	36.4
639	16	32.8

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of potato based on the 2 highest 15 year old age group consumers is 34.6 kg/y

The observed 97.5 percentile rate based on 2 observations is 36.3 kg/y

Table 30. Children's consumption rates of domestic fruit in the Rosyth area (kg/y)

15 year old age group

Observation number	Age	Rhubarb	Strawberry	Total
639	16	0.3	4.8	5.0

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of domestic fruit based on the only 15 year old age group consumer is 5.0 kg/y

The observed 97.5 percentile rate is not applicable for 1 observation

Table 31. Children's consumption rates of sheep meat in the Rosyth area (kg/y)

5 year old age group

Observation number	Age	Lamb
293	4	2.0
294	3	2.0
295	2	2.0

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of sheep meat based on the 3 highest 5 year old age group consumers is 2.0 kg/y

The observed 97.5 percentile rate based on 3 observations is 2.0 kg/y

Table 32. Children's consumption rates of wild/free foods in the Rosyth area (kg/y)

15 year old age group

Observation number	Age	Blackberry
598	14	0.2

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of wild/free foods based on the only 15 year old age group consumer is 0.2 kg/y

The observed 97.5 percentile rate is not applicable for 1 observation

Table 33. Children's consumption rates of venison in the Rosyth area (kg/y)

15 year old age group

Observation number	Age	Venison
598	14	0.6

Notes

Emboldened observations are the critical group consumers

The critical group consumption rate of venison based on the only 15 year old age group consumer is 0.6 kg/y

The observed 97.5 percentile rate is not applicable for 1 observation

Table 34. Percentage contribution each food type makes to its terrestrial food group for adults

Domestic fruit		Other vegetables		Eggs	
Strawberry	77.9 %	Runner bean	55.8 %	Chicken egg	100.0 %
Rhubarb	13.7 %	Pea	26.3 %	Wild fungi	
Raspberry	8.4 %	French bean	14.5 %	Mushrooms	100.0 %
Root vegetables		Broad bean	2.3 %	Poultry	
Onion	24.3 %	Sweetcorn	1.0 %	Pheasant	79.6 %
Leek	20.9 %	Green vegetables		Pigeon	20.4 %
Carrot	16.2 %	Cabbage	35.3 %	Rabbits/hares	
Turnip	14.9 %	Broccoli	24.9 %	Rabbit	100.0 %
Beetroot	9.8 %	Courgettes	12.4 %	Wild/free foods	
Swede	8.5 %	Cauliflower	9.1 %	Raspberry	71.4 %
Parsnip	2.3 %	Marrow	8.4 %	Blackberry	28.6 %
Spring onion	2.1 %	Brussel sprout	5.7 %		
Kohl rabi	0.9 %	Lettuce	3.3 %		
Garlic	0.04 %	Chard	0.9 %		
Fennel	0.04 %				

Notes

Percentages are based on the consumption of all adults in the survey consuming that particular food group

Table 35. Intertidal occupancy rates in the Rosyth area (h/y)

Observation number	Location	Activity	Boat over mud	Mud	Mud and sand	Rock	Sand and stones
1229	Charlestown Harbour East	Boat maintenance	624				
1228	Charlestown Harbour West	Boat maintenance	117				
175	Port Edgar	Boat dwelling	60				
1073	Kincardine	Salmon netting		423			
176	Torry Bay	Wildfowling		105			
349	Blackness Bay	Wildfowling		100			
348	Blackness Bay	Wildfowling		90			
575-584	Blackness Bay	Working on the shore		60			
1084-1096	Dalgety Bay	Bait digging		52			
13	Blackness Bay	Wildfowling		40			
254-284	Various beaches	Coastguard duties			305		
1108	Dalgety Bay/North Queensferry	Bait digging/angling			130		130
104	Cramond	Bait digging			104		
103	Cramond	Bait digging			48		
1097	St David's Harbour area/Aberdour	Shellfish collecting			40		20
100	Cramond	Bait digging			36		
98	Silverknowles and Cramond	Bait digging			24		
101-102	Cramond	Bait digging			24		
148	Cramond	Dog walking					1092
149	Cramond	Dog walking					365
1077-1078	Burntisland	Dog walking					350
1118-1119	Burntisland	Beach cleaning					347
124	South Queensferry	Beach cleaning					200
162	Cramond Island/various beaches	Shellfish collecting/angling				84	72
165	Cramond	Dog walking					144
17	Silverknowles and Cramond	Dog walking					87
146-147	Various beaches	Playing					52
174	Hound Point/South Queensferry	Angling/bait digging					49
153	Cramond	Walking					48
664-665	Blackness Bay	Walking					45
177-178	Aberdour	Playing					36
666-668	Blackness Bay	Playing					30
125-127	South Queensferry	Playing					25
143-144	Cramond Island	Bait digging					16

Table 35. Intertidal occupancy rates in the Rosyth area (h/y)

Observation number	Location	Activity	Boat over mud	Mud	Mud and sand	Rock	Sand and stones
138-139	Cramond Island	Bait digging					15
99	Cramond	Bait digging			13		
145	Cramond Island	Bait digging					12
163-164	Cramond Island	Shellfish collecting				12	
18-19	Cramond	Walking					10
151-152	Cramond	Playing					10
672	Various beaches	Walking					10
673	Various beaches	Walking					10
23-74	Cramond	Working on the shore					6
150	Cramond	Walking					6
154-157	Cramond	Walking					6
158-161	Cramond	Walking					4
137	Cramond Island	Bait digging					3
140-142	Cramond Island	Bait digging					3
20-22	Cramond	Dog walking					2
15-16	Silverknowles	Walking					1
166	Cramond Island	Jogging				1	

Notes

Emboldened observations are the critical group members

The critical group intertidal occupancy rate on boats over mud based on 3 observations is 270 h/y

The observed 97.5 percentile rate based on 3 observations on boats over mud is 599 h/y

The critical group intertidal occupancy rate over mud based on 1 observation is 423 h/y

The observed 97.5 percentile rate based on 28 observations for mud is 208 h/y

The critical group intertidal occupancy rate over mud and sand based on 33 observations is 294 h/y

The observed 97.5 percentile rate based on 40 observations for mud and sand is 305 h/y

The critical group intertidal occupancy rate over rock based on 1 observation is 84 h/y

The observed 97.5 percentile rate based on 4 observations for rock is 79 h/y

The critical group intertidal occupancy rate over sand and stones based on 2 observations is 729 h/y

The observed 97.5 percentile rate based on 107 observations for sand and stones is 350 h/y

Table 36. Handling rates of fishing gear and sediment in the Rosyth area (h/y)

Observation number	Location	Activity	Fishing gear	Sediment
1069	Rosyth	Gear handling	1170	
1064	Burntisland	Gear handling	936	
303	East of Queensferry	Gear handling	780	
306	East of Queensferry	Gear handling	780	
1070	Kincardine	Gear handling	455	
1071-1073	Kincardine	Gear handling	423	
1108	Dalgety Bay	Bait digging		130
176	Torry Bay	Wildfowling		105
104	Cramond	Bait digging		104
1224	Kinghorn	Gear handling	102	
1226-1227	Kinghorn	Gear handling	102	
349	Blackness Bay	Wildfowling		100
348	Blackness Bay	Wildfowling		90
1097	Aberdour, St David's Harbour area	Mollusc collecting		60
1084-1096	Dalgety Bay	Bait digging		52
1103	North Queensferry	Gear handling	52	
103	Cramond	Bait digging		48
13	Blackness Bay	Wildfowling		40
100	Cramond	Bait digging		36
1100	St David's Harbour area	Gear handling	34	
174	South Queensferry	Bait digging		31
98	Silverknowles and Cramond	Bait digging		24
101-102	Cramond	Bait digging		24
143-144	Cramond Island	Bait digging		16
138-139	Cramond Island	Bait digging		15
99	Cramond	Bait digging		13
145	Cramond Island	Bait digging		12
162-164	Cramond Island	Shellfish collecting		12
137	Cramond Island	Bait digging		3
140-142	Cramond Island	Bait digging		3

Notes

Emboldened observations are the critical group members

The critical group fishing gear handling rate based on 8 observations is 674 h/y

The observed 97.5 percentile rate based on 13 observations for fishing gear is 1100 h/y

The critical group sediment handling rate based on 20 observations is 66 h/y

The observed 97.5 percentile rate based on 39 observations for sediment is 106 h/y

Table 37. Gamma dose rate measurements over intertidal substrates in the Rosyth area (µGy/h)

NGR	Location	Substrate	µGy/h
NT 927 873	Kincardine Slipway	Mud	0.068
NT 245 856	Burntisland	Sand	0.051
NT 202 853	Aberdour Harbour	Mud and sand	0.055
NT 195 852	Aberdour - Silver Sands Bay	Sand	0.053
NT 195 775	Cramond	Mud and sand	0.048
NT 142 825	St Davids Harbour area - near quarry	Mud	0.059
NT 121 788	Port Edgar Marina	Mud	0.052
NT 121 788	In boat at Port Edgar Marina	Mud	0.053
NT 065 834	Charlestown Harbour East	Mud	0.056
NT 050 805	Blackness Bay	Sand	0.059

Table 38. Occupancy rates in and on water in the Rosyth area (h/y)

Observation number	Location	Activity	In water	On water
1079-1083	Burntisland	Diving	50	
179	Burntisland/Dalgety Bay	Diving/Boating	3	51
180	Dalgety Bay/Burntisland	Boating/Diving	3	51
575-584	Various areas	Working on a boat/Diving	2	10
175	Port Edgar	Boat dwelling		6975
204-253	Clydeport Operations Ltd	Working on a boat		2016
105-114	South Queensferry to Oil rig	Working on a boat		1820
585-588	From South Queensferry	Working on a boat		1500
1069	Rosyth	Commercial fishing		1170
303	East of Queensferry	Commercial fishing		1040
306-307	East of Queensferry	Commercial fishing		1040
1064	Burntisland	Commercial fishing		936
115-120	South Queensferry to Inchcolm Island	Working on a boat		800
571-573	From Port Edgar	Working on a boat		780
1229	Charlestown Harbour East	Boat maintenance		624
574	From Port Edgar	Working on a boat		585
1070	Kincardine	Commercial fishing		455
1071-1072	Kincardine	Commercial fishing		423
170-171	Burntisland	Angling		312
167-169	From South Queensferry	Boating		300
308-347	From River Almond	Boating		280
1228	Charlestown Harbour West	Boat maintenance		233
1-12	From Blackness	Boating		156
353-451	From Port Edgar	Boating		125
25-74	From Granton Harbour	Boating		110
1224	Kinghorn	Angling		102
1226-1227	Kinghorn	Angling		102
644-645	In aquatic survey area	Angling		100
121-123	South Queensferry to Inchcolm Island	Working on a boat		73
1100	St David's Harbour area	Commercial fishing		68
553-570	From South Queensferry	Working on a boat		67
75-86	From Granton Harbour	Boating		65
452-552	From Port Edgar	Boating		63
1103	North Queensferry	Commercial fishing		52

Table 39. Occupancy rates in the Rosyth direct radiation survey area (h/y)

Observation number	Sex (U if unknown)	Age in Years (U if unknown)	National Grid Reference	Location	Distance	Indoor occupancy (h/y)	Outdoor occupancy (h/y)	Total occupancy (h/y)
Adult observations								
92	M	48	NT 101 830	Dundonald Road	0.60	8424		8424
670	F	57	NT 101 830	Dundonald Road	0.70	7980	260	8240
626	M	56	NT 103 829	Laurel Road	0.70	7630	360	7990
672	F	48	NT 101 830	Dundonald Road	0.70	7754	100	7854
177	F	61	NT 103 829	Forbes Road	0.75	7048	730	7778
93	F	22	NT 101 830	Dundonald Road	0.60	7624	100	7724
658	F	35	NT 103 828	Forbes Road	0.65	6900	700	7600
659	M	47	NT 103 828	Forbes Road	0.65	6958	590	7548
131	F	32	NT 104 828	Forbes Road	0.75	7128	240	7368
88	F	47	NT 102 829	Laurel Road	0.60	6240	864	7104
663	M	59	NT 103 828	Forbes Road	0.65	6820	260	7080
129	F	55	NT 103 828	Forbes Road	0.75	7008	72	7080
89	F	45	NT 103 829	Forbes Road	0.70	6086	912	6998
134	F	37	NT 104 828	Somerville Road	0.85	5580	1200	6780
662	M	61	NT 103 828	Forbes Road	0.65	6500	260	6760
629	F	60	NT 101 830	Dundonald Road	0.70	6027	685	6712
625	F	53	NT 103 829	Laurel Road	0.70	6534	140	6674
631	F	46	NT 101 830	Dundonald Road	0.60	6338	220	6558
133	M	38	NT 104 828	Somerville Road	0.85	5580	720	6300
87	M	50	NT 102 829	Laurel Road	0.60	5968	160	6128
180	F	29	NT 101 830	Dundonald Road	0.70	6008	100	6108
673	M	44	NT 101 830	Dundonald Road	0.70	5870	230	6100
655	F	46	NT 103 829	Forbes Road	0.65	5876	150	6026
627	F	17	NT 103 829	Laurel Road	0.70	5449	340	5789
657	M	21	NT 103 829	Forbes Road	0.65	5676	100	5776
95	M	45	NT 101 830	Dundonald Road	0.60	5187	365	5552
96	F	40	NT 101 830	Dundonald Road	0.60	4274	1278	5552
130	M	29	NT 104 828	Forbes Road	0.75	5112	240	5352
630	M	53	NT 101 830	Dundonald Road	0.70	5067	245	5312
94	M	22	NT 101 830	Dundonald Road	0.60	5168	100	5268
669	M	55	NT 101 830	Dundonald Road	0.70	4950	170	5120
128	M	59	NT 103 828	Forbes Road	0.75	4928	72	5000
654	M	49	NT 103 829	Forbes Road	0.65	4724	150	4874
178	M	51	NT 103 829	Forbes Road	0.75	4604	263	4867
656	F	19	NT 103 829	Forbes Road	0.65	4410	50	4460
632	M	48	NT 101 830	Dundonald Road	0.60	4120	220	4340
1171	M	45	NT 098 825	Mainbrace, RBP	0.30	1715	1715	3430
90	F	20	NT 103 829	Forbes Road	0.70	3154	38	3192
1218	F	43	NT 098 825	Arnold Clarke Vehicles, RBP	0.30	2277		2277
179	M	33	NT 101 830	Dundonald Road	0.70	2091	40	2131
1179-1195	M	U	NT 098 825	Peebles, RBP	0.30	2025		2025
1196-1213	F	U	NT 098 825	Peebles, RBP	0.30	2025		2025
204-253	M	U	NT 098 819	Clydeport Operations Ltd	0.50	202	1814	2016

Table 39. Occupancy rates in the Rosyth direct radiation survey area (h/y)

Observation number	Sex (U if unknown)	Age in Years (U if unknown)	National Grid Reference	Location	Distance	Indoor occupancy (h/y)	Outdoor occupancy (h/y)	Total occupancy (h/y)
Adult observations								
201	M	58	NT 098 819	Clydeport Operations Ltd	0.50	940	940	1880
202	M	40	NT 098 819	Clydeport Operations Ltd	0.50	188	1692	1880
203	M	42	NT 098 819	Clydeport Operations Ltd	0.50	188	1692	1880
182-198	F	U	NT 106 824	Inova Way	0.90	1590	250	1840
694-701	U	U	NT 104 824	Forth Ports Plc, Port of Rosyth	0.70	1840		1840
702-739	U	U	NT 104 824	Forth Ports Plc, Port of Rosyth	0.70	550	1290	1840
740743	U	U	NT 104 824	Lafarge, Port of Rosyth	0.70	1840		1840
1120-1129	F	U	NT 098 825	DEW, RBP	0.30	1840		1840
1130-1140	M	U	NT 098 825	DEW, RBP	0.30	1840		1840
1214-1217	M	U	NT 098 825	Focus Support, RBP	0.30	1840		1840
1141-1154	F	U	NT 098 825	OHSAS, RBP	0.30	1826		1826
1155-1165	M	U	NT 098 825	OHSAS, RBP	0.30	1826		1826
680	U	U	NT 096 826	IMES, RBP	0.10	900	900	1800
686-693	U	U	NT 096 826	IMES, RBP	0.10	900	900	1800
760	U	U	NT 102 823	Points North, RBP	0.50	1800		1800
797-825	U	U	NT 100 828	Babcock Lauder Technology, RBP	0.60	1750		1750
744-756	U	U	NT 108 241	Denhols, Port of Rosyth	0.70	1725		1725
1172	M	U	NT 098 825	Mainbrace, RBP	0.30	1725		1725
1173	M	U	NT 098 825	Mainbrace, RBP	0.30	1294	431	1725
675-679	U	U	NT 096 826	Acetech, RBP	0.10	1700		1700
762-796	U	U	NT 100 828	Babcock Lauder Technology, RBP	0.60	1520		1520
199-200	F	U	NT 106 824	Building Blocks Nursery	0.90	1130	250	1380
1174-1178	M	U	NT 098 825	IT, RBP	0.30	1080		1080
827-977	U	U	NT 100 828	Babcock Lauder Technology, RBP	0.60	756		756
1166-1169	M	U	NT 098 825	OHSAS, RBP	0.30	748		748
1170	F	U	NT 098 825	OHSAS, RBP	0.30	748		748
757-759	U	U	NT 102 823	Points North, RBP	0.50	450		450
978-1061	U	U	NT 100 828	Babcock Lauder Technology, RBP	0.60	300		300
1219	M	U	NT 098 825	Arnold Clarke Vehicles, RBP	0.30	11	217	228
Child observations								
97	F	15	NT 101 830	Dundonald Road	0.60	5524	980	6504
660	M	16	NT 103 828	Forbes Road	0.65	4593	1480	6073
661	M	15	NT 103 828	Forbes Road	0.65	5589	620	6209
181	M	1	NT 101 830	Dundonald Road	0.70	7478	100	7578
135	F	4	NT 104 828	Somerville Road	0.85	4980	1200	6180
136	M	3	NT 104 828	Somerville Road	0.85	4980	1200	6180
91	M	15	NT 103 829	Forbes Road	0.70	6062	100	6162
633	M	15	NT 101 830	Dundonald Road	0.60	5556	1000	6556
132	F	12	NT 104 828	Forbes Road	0.75	4137	1011	5148
628	F	16	NT 103 829	Laurel Road	0.70	6199	340	6539
671	M	4	NT 101 830	Dundonald Road	0.70	7460	260	7720

RBP = Rosyth Business Park

Table 40. Gamma dose rate measurements for the Rosyth direct radiation survey ($\mu\text{Gy/h}$)

Location	Indoor substrate	$\mu\text{Gy/h}$	Outdoor substrate	$\mu\text{Gy/h}$
Dundonald Road	concrete	0.114	N/M	N/M
Dundonald Road	concrete	0.112	N/M	N/M
Dundonald Road	concrete	0.111	grass	0.096
Dundonald Road	wood	0.117	N/M	N/M
Dundonald Road	wood	0.113	grass	0.087
Dundonald Road	concrete	0.106	grass	0.082
Laurel Road	concrete	0.097	grass	0.083
Laurel Road	concrete	0.114	grass	0.081
Forbes Road	N/M	N/M	grass	0.080
Forbes Road	N/M	N/M	grass	0.079
Forbes Road	concrete	0.104	grass	0.073
Forbes Road	concrete	0.104	N/M	N/M
Forbes Road	concrete	0.114	N/M	N/M
Somerville Road	concrete	0.118	N/M	N/M
Building Blocks Nursery School	concrete	0.068	grass	0.068
Clydeport Operations (coal terminal)	Portacabin	0.054	tarmac	0.076

N/M = Not measured

Comparison background gamma dose rates

NGR	Location and substrate	$\mu\text{Gy/h}$
NT 085 779	Position 1 over grass - near Abercorn	0.064
NT 085 780	Position 2 over grass - near Abercorn	0.069

Table 41. Ratios for determining consumption rates for children

Food group	Ratio child/adult ⁽¹⁾	
	1 yr old	10 yr old
Fish ⁽²⁾	0.050	0.200
Crustaceans ⁽²⁾	0.050	0.250
Molluscs ⁽²⁾	0.050	0.250
Green vegetables	0.222	0.444
Other vegetables	0.200	0.500
Root vegetables	0.375	0.500
Potatoes	0.292	0.708
Domestic fruit	0.467	0.667
Milk	1.333	1.000
Cattle meat	0.222	0.667
Pig meat	0.138	0.625
Sheep meat	0.120	0.400
Poultry	0.183	0.500
Eggs	0.600	0.800
Wild/free foods ⁽³⁾	0.110	0.490
Game ⁽⁴⁾	0.140	0.500
Honey	0.789	0.789
Wild fungi	0.150	0.450
Freshwater fish ⁽²⁾	0.050	0.250
Direct radiation	1.000	1.000
External exposure	0.500	0.030
Plume	1.000	1.000

Notes

1. The age groups suggested for assessment in this table are those relating to dose coefficients representing 1 to 2 yr olds (labelled 1 yr old) and 7 to 12 yr olds (labelled 10 yr old). Excepting notes 2 and 3, ratios were derived from Byrom et al., (1995) for 1yr old (6 - 12 months) and 10 yr old children (10 - 11 yrs).
2. Ratios were derived from Smith and Jones, (2003) which presented data for infants and children.
3. Ratios were derived from FSA, (2002) data for wild fruit and nuts for infants and 10 yr old children.
4. Game includes rabbits/hares and venison.

Annex 2. Children's consumption rates (kg/y or l/y) and occupancy rates (h/y) in the Rosyth area

Observation number	Sex (U if unknown)	Age in years	Distance from site	Fish	Wildfowl	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Sheep meat	Wild/free foods	Venison	Intertidal occupancy over rock	Intertidal occupancy over sand	Handling sediment	Indoor occupancy	Outdoor occupancy
15 year old age group																		
628	F	16	0.7														6199	340
639	F	16	6.0			13.2	1.1	15.7	32.8	5.0								
660	M	16	0.7														4593	1480
1112	F	16	U	6.9														
91	M	15	0.7														6062	100
97	F	15	0.6														5524	980
633	M	15	0.6														5556	1000
661	M	15	0.7														5589	620
351	M	14	U	2.6														
598	F	14	5.5			0.8						0.2	0.6					
608	F	14	U			7.5	8.1	5.4	36.4									
1111	F	14	U	6.9														
163	F	13	U											12		12		
352	F	13	U	2.6														
132	F	12	0.8														4137	1011
10 year old age group																		
160	F	9	13.0												4			
164	F	9	U											12		12		
21	F	8	11.0												2			
147	M	7	9.0												52			
5 year old age group																		
127	M	6	U												25			
161	F	6	13.0												4			
19	M	5	16.0												10			
156	F	5	13.0												6			
668	M	5	U												30			
135	F	4	0.9														4980	1200
293	F	4	U								2.0							
671	M	4	0.7														7460	260
136	M	3	0.9														4980	1200
157	F	3	13.0												6			
294	F	3	U								2.0							
667	F	3	U												30			
22	F	2	11.0												2			
295	M	2	U								2.0							
1 year old age group																		
152	F	1	12.0												10			
181	M	1	0.7														7478	100

Annex 3. Combinations of adult groups for consideration in dose assessments in the Rosyth area

Combination number	Fish	Crustaceans	Molluscs	Marine plants and algae	Wildfowl	Green vegetables	Other vegetables	Root vegetables	Potato	Domestic fruit	Cattle meat	Sheep meat	Poultry	Eggs	Wild/free foods	Rabbits/hares	Honey	Wild fungi	Venison	Intertidal occupancy in a boat over mud	Intertidal occupancy over mud and sand	Intertidal occupancy over mud	Intertidal occupancy over rock	Intertidal occupancy over sand and stones	Handling fishing gear	Handling sediment	Occupancy in water	Occupancy on water	Indoor occupancy	Outdoor occupancy		
1																								*								
2				*	*																	*			*							
3																								*						*	*	
4	*		*																			*		*	*							
5																							*		*							
6	*					*	*	*					*			*									*				*			
7	*	*																						*		*						
8																					*								*			
9																												*	*	*	*	
10												*										*										
11													*	*	*						*											
12		*	*																						*				*			
13																						*					*	*				
14																	*															
15									*		*																					
16						*									*				*													
17						*	*	*	*	*										*												
18	*					*	*	*	*	*																						
19	*	*																								*			*			
20	*																					*				*						

